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DI ROMA “LA SAPIENZA”
Dipartimento di Scienze dell’Antichità
Dipartimento di Scienze della Terra

La Terra degli Elefanti

The World of Elephants

Atti del 1° Congresso Internazionale
Proceedings of the 1st International Congress

a cura di:
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Preface

As A.S. Romer wrote in his *Vertebrate Paleontology* in 1966, "*one of the most spectacular stories in mammalian evolution is that of the order Proboscidea*". In fact, in the course of their long and complex evolution over approximately 55 million years, the Proboscideans have evolved in the most different directions, with at least three main radiation phases that have given rise to phenomena of convergence in evolution, to extremely specialized forms, and to *taxa* of difficult phylogenetic classification. The Proboscideans have inhabited the most different environments, sometimes extreme, from semiacquatic environments, to deserts, to rain forests, to the savannah, to the tundra, often attaining a very wide geographical distribution. In this capacity of adaptation and diffusion they are similar to the far more recent Primates, that with *Homo spp.* represent the other side of the equation to which this Congress (whose proceedings we are presenting here) is addressed.

The decision to hold the 1st Congress "*The World of Elephants*" in Italy is justified by the exceptional quality of the palaeontological and archaeological evidence produced by sites with remains of *Elephas (Palaeoloxodon) antiquus*. The city of Rome itself, and its environs, is characterized by particularly significant deposits and important museum projects, such as La Polledrara di Cecanibbio (Torre in Pietra, Rome, *ca.* 350 ka) and Rebibbia - Casal de' Pazzi (Roma, *ca.* 250 ka), which will be open to the general public in the near future.

This context has led a large group of researchers (palaeontologists, archaeologists, geologists), who have been devoted for years to the study of the Campagna Romana, to review the progress of over a century of scientific activity and achieve a global view of the evolution of the area's climate and environment and the interaction between man and elephant during the Pleistocene.

Of the themes proposed for discussion at the Congress, the following met with a particularly vigorous response in the international scientific community:

- The most recent hypotheses and findings on the origin and classification of the Proboscidea order
- The complex problems connected with the processes of the reduction in size of elephants in insular environments
- The new analytical techniques and methodological approaches that are helping to better define a global view of the group's taxonomy
- The more exact definition of the habitat in which elephants lived and, more particularly, the so-called *mammoth steppe*
- The interaction between human groups and elephants of which we have evidence covering a span of some two million years in the form of remains of carcasses associated with prehistoric tools
- The utilization of elephant bones, which were flaked to produce tools as early as the Lower Palaeolithic and even used as building material in the Upper Palaeolithic
- the use of ivory and in particular mammoth ivory in the Italian peninsula during the Bronze Age
- The impact of elephants on the collective imagination in the historical period, from the Roman period onwards
- The problems of the conservation of the extant species of elephants

Scientific sessions

Session A is devoted to furnishing an overall picture of the aspects that characterize the Campagna Romana from a geological, geomorphological, palaeontological and archaeological point of view during the Quaternary. Particular emphasis is placed on the geological and palaeoenvironmental evolution, changes in fauna and the more ancient testimonies of human presence. A first attempted synthesis of the findings concerning the lithic industry, including the technological aspect, is presented. The study of some sites in the Campagna Romana, still in course, also permits previous knowledge to be re-examined in a fresh light and also highlights the scientific problems that still remain unresolved, linked in particular to the more primitive human types and the role that human groups have played in mammalian guilds.

Sessions B1-2-3 concern the Proboscideans and their habitat in the Plio-Pleistocene and offer a synthesis of the evolution of the elephant population in various geographical areas of the Old and New World. Of particular interest is the presentation of sites in East Africa, where the interaction between elephant and man is already documented almost 2 million years ago. The proliferation of finds of stone tools associated with carcass remains re-opens the problem of the exploitation of animal resources in such ancient periods; it also suggests the great attention paid by human groups to the opportunities for scavenging that presented themselves from time to time, also in competition with the activities of other and far more predatory carnivorous species. The presentation of recently discovered sites not only permits taphonomic and palaeoenvironmental aspects to be seen in a new perspective, but also confirms the existence of a first human colonization of the European continent dated 1 Ma ago or more, as well as continuity of settlement from at least 600 ka.
Some problems of taxonomic character still remain unresolved: for example, there is no agreement among experts on the taxonomic rank, generic or subgeneric, attributed to such extremely representative Quaternary *taxa* as *Archidiskodon* and *Palaeoloxodon.*

Session B4 concerns the Upper Pleistocene with ample space dedicated to the studies on the so-called *mammoth steppe*, both in its various palaeobotanical connotations and in terms of its fauna and archaeological evidence. Studies of detail are proposed, also on micromammals, birds and invertebrates, while some contributions provide an innovative view of the behaviour of the mammoth itself. Equally important is the documentation relating to the presence of similar environments at relatively low latitudes and even in the Mediterranean area.
Also included in the session are various communications and reports dedicated to various species of elephant, from the Far East to Africa and the New World. A certain consensus seems to be taking shape on the fact that at least a part of the elephants, especially the younger specimens, found in Upper Palaeolithic sites, from the New World to Asia and Europe, may have been actively hunted by human groups. But this does not exclude the opportunistic practice of scavenging.
One problem that still remains unresolved concerns the size of the last *Mammuthus primigenius*, including the insular forms found in the Wrangel isles (Russia), also in the light of the presence of examples of particularly small size in current species and of the separation of *Loxodonta cyclotis* at the level of species, discussed by J. Shoshani in the course of the 8th Theriological Congress (Sun City, South Africa, August 2001).

Session C is devoted to a discussion of what impact elephants have had as image and symbol in the course of the millennia, of how many legends they have given rise to, and how difficult it is in some cases to correctly interpret the data. Indicative of the difficulties in understanding experienced by the scientific community in the various periods of the past are the episodes linked to the acceptance, non-acceptance, or deformation, of the information concerning elephants, both as living species and as extinct species.

Workshops

The various issues tackled in the workshops are also of great range and interest. Three main themes can be recognized; first, the origin and the evolution both of the more ancient *taxa* and of species in particular environments, such as that of islands; second, the utilization for various purposes of elephant remains, including ivory, by human groups in the Palaeolithic and in more recent phases of prehistory; and third, the safeguard and conservation of living species.

New data have emerged on the origin of the group and the differentiation of the more ancient *taxa*. New techniques of analysis are being increasingly used to try to define the phylogenetic relationships. Alongside the classic morphological and biometric approaches, a number of advanced methodologies are gradually gaining ground, first and foremost the studies of DNA. Moreover, the study of anatomical details, for example hyoid apparatus, enamel and dentine structure, Schreger lines, have proved of great utility for an identification at least at the generic level or even as supporting evidence for phylogenetic hypotheses.

One major problem that still remains open concerns, however, the endemic *taxa* of the islands and their classification, which is shown to be even more complex wherever it is difficult to establish times and ways of colonization. Another controversial problem is the still hotly debated dynamic of the process that leads to size reduction.

From a more strictly archaeological point of view, one finding that clearly emerges is the use of flakes of elephant bone, and in some cases of ivory, that is far more widespread that previously thought: it already appears in the Lower Palaeolithic, but is also well attested during the Upper Palaeolithic, generally better known for tools of hard animal matter worked by abrasion and smoothing. As regards the Bronze Age, it is just the new techniques developed in the palaeontological sphere that have opened new horizons as regards a different source of ivory, and hence of a different pattern of trade and exchange.

From what has been said above, the need is also evident to preserve, for future generations, at least some of the more significant archaeological and palaeontological evidence concerning the interaction between Proboscideans and *Homo spp*. In this sense, the museum conservation of the finds at La Polledrara di Cecanibbio and Casal de' Pazzi is the premise, but also the conclusion, of the Congress's work.

Much has been achieved, but much still remains to be done. It is therefore to be hoped that this is only the first of a series of meetings, that may help in future to further elucidate the close link between climate, environment, evolution of the *taxa* and structure of the palaeo-communities, and the development of the interrelation between man and elephant through the various phases of prehistory and history, right down to the present management of the species.

With this hope, we wish you progress in your research, and look forward to meeting again, and reviewing our findings, at the 2nd International Congress "*The World of Elephants*".
Giuseppe Cavarretta, Patrizia Gioia, Margherita Mussi and Maria Rita Palombo
Roma, October 2001

Lithic and bone industries of OIS 9 and OIS 7 in the Roman area

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SUMMARY: Lithic and bone industries from the Middle Pleistocene sites of Castel di Guido, Torre in Pietra levels *m* and *d*, La Polledrara and Casal de' Pazzi are discussed. The earlier sites – except La Polledrara – show greater variety in the choice of lithic raw materials, related to the production of large tools such as handaxes. On the later sites a greater variability in tool typology is displayed and more complex flaking techniques are used.

1. INTRODUCTION

The two main concentrations of lower Palaeolithic sites discovered so far close to Rome are located close to the Via Aurelia, and in the lower Aniene Valley. Some of these sites came to light during the nineteenth century. Many more were discovered by quarrying or during public works in the first half of the last century and still more with the post-war urban expansion of the Italian capital. The second half of the twentieth century witnessed the first modern archaeological research carried out by A.C.Blanc and L.Cardini at Torre in Pietra (Malatesta ed. 1978), A.M. Radmilli at Castel di Guido (Radmilli & Boschian 1996), and by the Soprintendenza Archeologica di Roma at Casal de' Pazzi (Anzidei & Ruffo 1985) and La Polledrara di Cecanibbio (Anzidei *et al.* 1999; Anzidei *et al.* in press), which is still under excavation. Following geo-stratigraphic correlation (Caloi *et al.* 1998; De Rita & Zarlenga 2001) three sites - Castel di Guido, La Polledrara and Torre in Pietra level *m* belong to the Aurelia Formation and accordingly to isotope stage 9 (OIS 9). Torre in Pietra level *d* and Casal de' Pazzi, both in the Vitinia Formation, date to isotope stage 7 (OIS 7). The only site with a stratigraphic sequence including both isotope stages is Torre in Pietra.

2. THE SITES

2.1 Torre in Pietra

The Torre in Pietra prehistoric site lies close to the Via Aurelia some 26 km outside Rome (Fig. 1). The lower archaeological level *m* was excavated over an area of some two hundred square metres, and the upper level *d* over about forty square metres (Piperno & Biddittu 1978).

51 handaxes, 327 flakes, retouched flakes and pebble tools were retrieved from level *m*, while level *d* yielded up 734 lithic implements

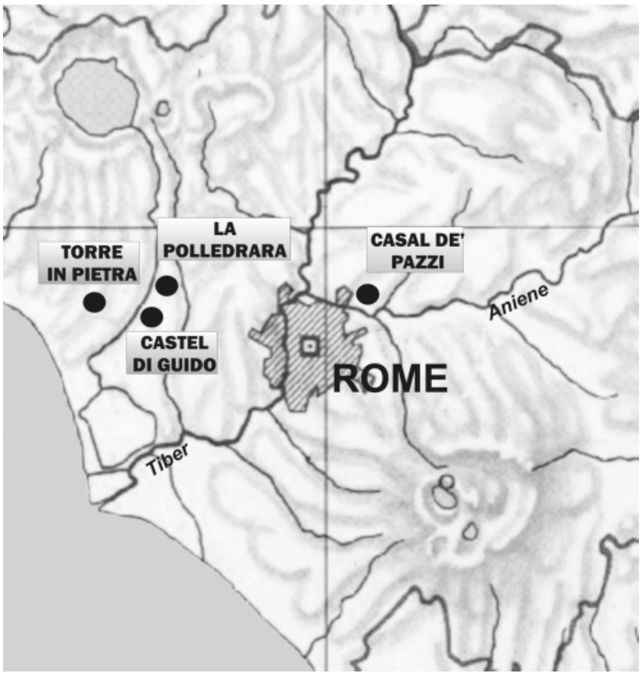


Fig.1 - Location of the sites.

(Piperno & Biddittu 1978). In both levels, lithic and faunal remains were distributed throughout the deposit (Caloi & Palombo 1978; Manzi *et al.* 2001). The finds from both levels were clearly reworked and often showed a considerable degree of rounding.

Volcanic tephra samples of *Tufo a pomici nere* from Torre in Pietra *m* were dated by K/Ar (KA 1185 and KA 304 = 431,000 BP; KA 334 = 434,000 BP; KA 345 = 438,000 BP) (Evernden & Curtis 1965). The dates are related to an eruption of the Bracciano volcano and cannot be taken as indicative of the age of the archaeological record.

2.2 Castel di Guido

The site, which lies some 20 km from Rome along the Via Aurelia (Fig. 1), was discovered during the Seventies. About 1200 square metres were excavated (Radmilli & Boschian 1996) and over 4000 archaeological and palaeontological finds retrieved. A level of silt rich in volcanic material later sealed the shallow basin in which the site is located. Of the 3000 bone remains, around 400 have been identified as tools. Most are handaxes, on top of 1300 lithic artefacts. A fair number of unmodified pebbles was also discovered, together with flakes, scrapers, handaxes, choppers and chopping tools. Five fragmentary human bones were found, belonging to a minimum of two individuals.

2.3 La Polledrara

La Polledrara di Cecanibbio (Fig. 1) is located between the Via Aurelia and Via Boccea, at about 20 km from Rome. It was discovered in 1984 during systematic surveys carried out by the Soprintendenza Archeologica di Roma and since 1985 over more than 700 square metres have been excavated. Over 9000 fossil bones, 400 lithic implements and a few bone tools have so far been discovered on a sector of a former seasonal watercourse, at its bottom as well as on its banks.

The finds had been washed downstream from their original position before being sealed under a layer of white limno-tuffitic clays derived from pyroclastic products. Shortly after this phase of fluvial activity, a marshy microenvironment came in existence. Some bones, a few of them still in anatomical connection, were found in the marshy layers. They belong to at least two elephants and a wolf. A few lithic artefacts were associated with the bones; their surface is fresh and in some cases use-wear traces are still visible.

2.4 Casal de' Pazzi

The Casal de' Pazzi site lies close to the present river Aniene (Fig. 1), between the Via Nomentana and the Via Tiburtina. It was uncovered during public construction work. Over 1200 square metres were excavated between 1981 and 1986 (Anzidei 1983; Anzidei & Ruffo 1985) uncovering a stretch of the ancient course of the river Aniene, filled by alternating layers of gravel and pyroclastic sand. Lithic industry and bones were randomly dispersed. A fragment of human skull, taken as representative of an archaic *Homo sapiens* (Manzi *et al.* 2001), was retrieved from the lowermost level. 2200 bones and over 1500 lithics were discovered. Due to the fluvial origin of the deposit, the finds are in secondary position and present at least four different degrees of rounding. There doesn't appear to be any correlation between the degree of rounding and the stratigraphic position.

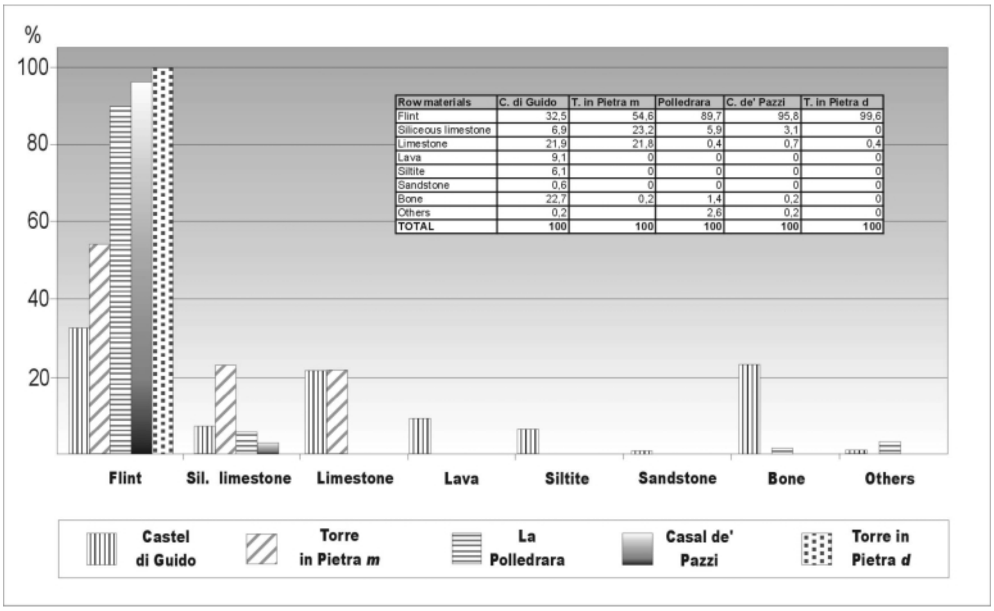
The lithic industry is currently under study and only a statistically representative sample of 451 implements is presented here (Anzidei & Gioia 1990).

3. COMPARISONS

Most of the statistical comparison is only feasible for four of the five archaeological assemblages quoted above. The technological and typological criteria used for Castel di Guido site differ in fact from all the others, not allowing full comparative analysis.

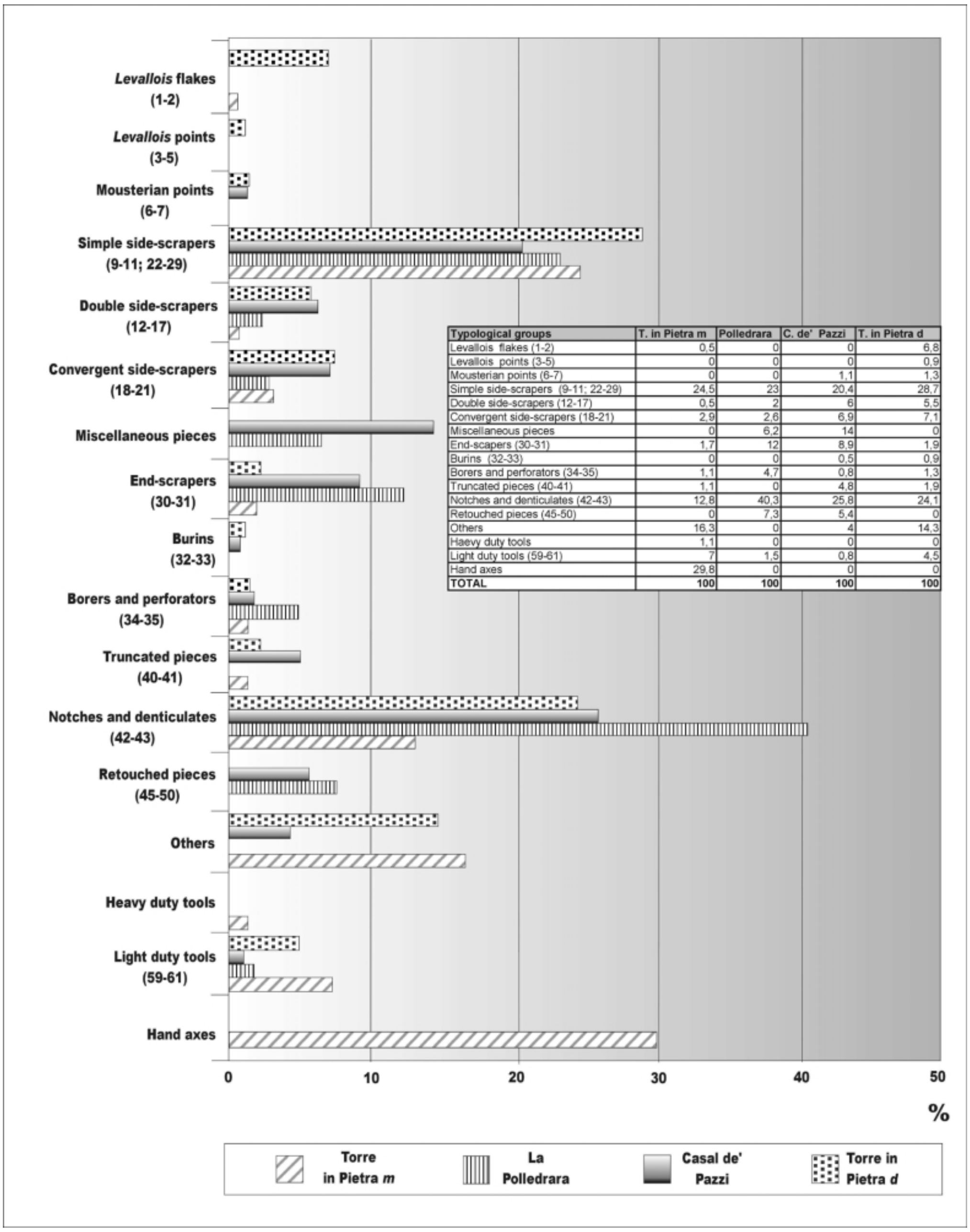
3.1 Raw materials (Fig. 2)

Small flint and silicified limestone pebbles are the most frequently used raw material. They are not easily found in a mostly volcanic depositional environment, and accordingly they were introduced on site by humans (Anzidei *et al.* 1999). Peculiar flint pebbles used to manufacture part of the tools of Casal de' Pazzi are the exception to the rule, as they have been col-



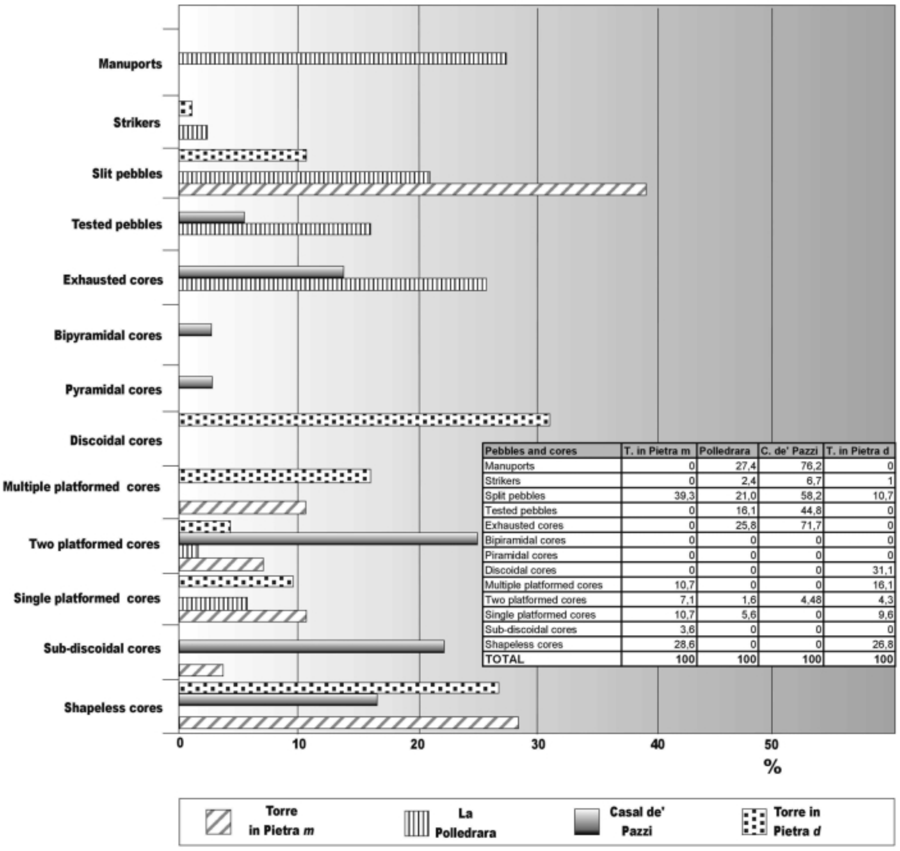
Row materials	C. di Guido	T. in Pietra m	Polledrara	C. de' Pazzi	T. in Pietra d
Flint	32,5	54,6	89,7	95,8	99,6
Siliceous limestone	6,9	23,2	5,9	3,1	0
Limestone	21,9	21,8	0,4	0,7	0,4
Lava	9,1	0	0	0	0
Siltite	6,1	0	0	0	0
Sandstone	0,6	0	0	0	0
Bone	22,7	0,2	1,4	0,2	0
Others	0,2		2,6	0,2	0
TOTAL	**100**	**100**	**100**	**100**	**100**

Fig.2 - Raw materials.



Typological groups	T. in Pietra m	Polledrara	C. de' Pazzi	T. in Pietra d
Levallois flakes (1-2)	0,5	0	0	6,8
Levallois points (3-5)	0	0	0	0,9
Mousterian points (6-7)	0	0	1,1	1,3
Simple side-scrapers (9-11; 22-29)	24,5	23	20,4	28,7
Double side-scrapers (12-17)	0,5	2	6	5,5
Convergent side-scrapers (18-21)	2,9	2,6	6,9	7,1
Miscellaneous pieces	0	6,2	14	0
End-scapers (30-31)	1,7	12	8,9	1,9
Burins (32-33)	0	0	0,5	0,9
Borers and perforators (34-35)	1,1	4,7	0,8	1,3
Truncated pieces (40-41)	1,1	0	4,8	1,9
Notches and denticulates (42-43)	12,8	40,3	25,8	24,1
Retouched pieces (45-50)	0	7,3	5,4	0
Others	16,3	0	4	14,3
Haevy duty tools	1,1	0	0	0
Light duty tools (59-61)	7	1,5	0,8	4,5
Hand axes	29,8	0	0	0
TOTAL	**100**	**100**	**100**	**100**

Fig.3 - Typological groups.



Pebbles and cores	T. in Pietra m	Polledrara	C. de' Pazzi	T. in Pietra d
Manuports	0	27,4	76,2	0
Strikers	0	2,4	6,7	1
Split pebbles	39,3	21,0	58,2	10,7
Tested pebbles	0	16,1	44,8	0
Exhausted cores	0	25,8	71,7	0
Bipiramidal cores	0	0	0	0
Piramidal cores	0	0	0	0
Discoidal cores	0	0	0	31,1
Multiple platformed cores	10,7	0	0	16,1
Two platformed cores	7,1	1,6	4,48	4,3
Single platformed cores	10,7	5,6	0	9,6
Sub-discoidal cores	3,6	0	0	0
Shapeless cores	28,6	0	0	26,8
TOTAL	**100**	**100**	**100**	**100**

Fig.4 - Cores.

lected from the alluvial deposits present on the site. Pebble utilisation led to a widespread use of the bipolar flaking technique (Cancellieri *et al.* 2001). Larger tools such as handaxes were mostly obtained using other raw materials beside flint: limestone cobbles and even large fragments of elephant bone diaphysis. At Torre in Pietra *m*, the only assemblage for which such detailed information is available, limestone cobbles are used in 76,4% of instances, flint cobbles in 15,6% of instances and siliceous limestone cobbles in just 7,8% of instances. Both Torre in Pietra *m* and Castel di Guido suggest that the same raw materials used for handaxes also led to the production of flake tools. The source of the limestone and siliceous limestone cobbles has not yet been found.

3.2 Typology

F. Bordes (1961) typology was used for the lithic tools, and various scraper types have been further grouped (Fig. 3). The evidence relative to cores is presented in Fig. 4.

Tab.1 - Bone tools.

Bone tools	C. di Guido	T. in Pietra *m*	Polledrara	C. de' Pazzi	T. in Pietra *d*
Hand axes	99	0	0	0	0
Scrapers	11	0	2	0	0
Others	263	1	5	1	0
TOTAL	**373**	**1**	**7**	**1**	**0**

It should be noted that there are very few bone tools except at Castel di Guido (Tab. 1). Handaxes, most notably, which have also been reported in the earlier Acheulean site of Fontana Ranuccio, less than 50 km South of Rome (Biddittu & Segre 1982), are only found at this site. Another specimen was discovered at Malagrotta, a nearby minor site (Cassoli *et al.* 1982). Most of the bone tools of Castel di Guido, however, are scarcely elaborated items.

4. CONCLUSIONS

In spite of their varying chronological position and environmental setting (De Rita & Zarlenga 2001; Follieri & Magri 2001), the sites are all characterised by water activity and hydraulic disturbance. Lakes, rivers, ephemeral streams characterised the environment, and while partially destroying the evidence, also facilitated their preservation (Arnoldus-Huyzendveld *et al.* 2001). This also resulted in a good preservation of faunal remains, always including a fair amount of *Elephas (Palaeoloxodon) antiquus* bone.

Lithic assemblages show great variety, even within the same isotope stage. As far as typology is concerned, simple scrapers and notches/denticulates make the majority of tools in all sites. The remaining lithic assemblage varies from site to site. Both Castel di Guido and Torre in Pietra *m* include a substantial number of handaxes (many being bone handaxes at Castel di Guido), which are not found at La Polledrara. At the latter site there are fair numbers of borers, perforators and end-scrapers, while both notches and denticulates might be, at least in part, pseudo-tools resulting from water transport and deposition. A good number of two-platformed cores, as well as discoidal cores, are found at Torre in Pietra level *d*, which also stands out for the evidence of *Levallois* prepared-core technique. Putting aside the lack of any *Levallois* technique, the record of Casal de' Pazzi is quite similar to that of Torre in Pietra *d*. There is, furthermore, a substantial number of sub-discoidal cores and of two-platformed cores at Casal de' Pazzi. At this site, the *demi-Quina* retouch is rather frequent, as opposed to the rarer *Quina* retouch.

The typological diversification and technological standardisation of the later sites (OIS 7) is in parallel with increasing specialisation in the choice of raw materials, which is highly diversified in the earlier (OIS 9) sites and quite exclusive in the more recent ones. The need to manufacture large tools probably also played a role in the OIS 9 assemblages, as cobbles of various lithology were searched for. It should be underlined that on top of chronological distance among sites, any variability of the lithic industry is also the result of activity diversification, raw material availability and interaction with the natural environment.

5. REFERENCES

Anzidei, A.P. 1983. *Casal de' Pazzi, Lazio, in "I primi abitanti d'Europa", Roma*: 202-207.

Anzidei, A.P., Arnoldus-Huyzendveld, A., Caloi, L., Palombo, M.R., Lemorini, C. 1999. Two Middle Pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia - Casal de' Pazzi. In *The role of early humans in the accumulation of European Lower and Middle Palaeolithic bone assemblages*: 173-195. Mainz: Römisch-Germanischen Zentralmuseums.

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Mussi, M. & Palombo, M.R., in press. Nouvelles Données sur le gisement Pleistocène moyen de La Polledrara di Cecanibbio (Latium, Italie). In *Actes du Colloque International de Tautavel sur "Les Premiers habitants de l'Europe" (10-15 avril 2000)*.

Anzidei, A.P. & Gioia, P. 1990. The lithic industry from Rebibbia-Casal de' Pazzi. In *Paper of the Fourth Conference of Italian Archaeology, New Developments in Italian Archaeology*, Part 1: 155-179.

Anzidei, A.P. & Ruffo, M. 1985. The Pleistocene deposit of Rebibbia- Casal de' Pazzi (Rome, Italy). In C. Malone and S. Stoddart (eds.), *Papers in Italian Archaeology*. IV: part I. *The human landscape, BAR i.s.*, 243: 69-85.

Arnoldus-Huyzendveld, A., Zarlenga, F., Gioia, P., Palombo, M.R. 2001. Distribution in space and time and analysis of preservation factors of the Pleistocene deposits. *This volume.*

Biddittu, I. & Segre, A.G. 1982. Pleistocene medio-inferiore con industria litica arcaica su ciottolo nel bacino di Anagni (Lazio). In *Atti della XXIII° Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria*: 567-576.

Blanc, A.C. 1954. Giacimento ad industria del Paleolitico inferiore (Abbevilliano superiore ed Acheuleano) e fauna fossile ad *Elephas* a Torre in Pietra presso Roma (Nota prelim.). *Rivista di Antropologia*, 41: 345-353.

Bordes, F. 1961. *Typologie du Paléolithique ancien et moyen*. Delmas: Publication de l'Institut de Préhistoire de l'Université de Bordeaux.

Caloi, L. & Palombo, M.R. 1978. Anfibi, rettili e mammiferi di Torre del Pagliaccetto (Torre in Pietra, Roma). In Malatesta A. (ed.), Torre in Pietra, Roma. *Quaternaria* XX: 315-428.

Caloi, L., Palombo, M., Zarlenga, F. 1998. Late Middle Pleistocene mammal faunas of Latium (Central Italy): Stratigraphy and Environment. *Quaternary International* 47-48: 77-86.

Cancellieri, E., Coppola, A., D'Angelo, E., Di Leo, R., Rinaldi, M.F., Rossi, D. 2001. La tecnica di scheggiatura bipolare applicata ai ciottoli - Considerazioni su un lavoro di scheggiatura sperimentale. *This volume*.

Cassoli, P.F., De Giuli, C., Radmilli, A.M., Segre, A.G. 1982. Giacimento del Paleolitico inferiore a Malagrotta (Roma). In *Atti della XXIII° Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria*: 531-549.

De Rita, D. & Zarlenga, F. 2001. Middle Pleistocene geology of the “bassa campagna romana”. *This volume*.

Evernden, J.F., Curtis, G.H. 1965. The Potassium Argon dating of late Cenozoic Rocks in East Africa and Italy. *Current Anthropology* 6, 4: 343-385.

Follieri, M., Magri, D. 2001. Middle and Upper Pleistocene natural environment in the Rome area: climate, vegetation and landscape. *This volume*.

Malatesta, A. (ed.) 1978, Torre in Pietra, Roma. *Quaternaria* XX.

Manzi, G., Palombo, M.R., Caloi, L., Mallegni, F. 2001. Transitions in human evolution and faunal changes during the Pleistocene in Latium. *This volume*.

Piperno, M. & Biddittu, I. 1978. Studio tipologico ed interpretazione dell’industria acheuleeana e pre-musteriana dei livelli m e d di Torre in Pietra (Roma). In Malatesta A. (ed.), *Torre in Pietra, Roma, Quaternaria* XX: 441-536.

Radmilli, A.M. & Boschian, G. 1996. *Gli scavi di Castel di Guido. Il più antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano*. Firenze: Istituto Italiano di Preistoria e Protostoria.

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Distribution in space and time and analysis of preservation factors of Pleistocene deposits in the Roman area

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SUMMARY: An overview is given of the distribution of the 12 major Lower Palaeolithic sites around Rome with both bones and artefacts. Regularities in their spatial distribution are traced, and the preservation and discovery conditions of the sites are analysed. Generally, the formation of the embedding sediments is recognised as a principal site-forming condition. It is stressed that in the "Campagna Romana", sedimentary conditions have been present only during very short periods of the Quaternary geological evolution. Also other factors for site "formation" -favourable living conditions, burial, fossilisation, and discovery- are analysed for this specific area. It is concluded that the present distribution of Lower Palaeolithic sites near Rome may be mainly due to events related to the local and regional geological and morphological evolution. It is remarked that, in order to gain insight in the real areas of frequentation of the "Campagna Romana", one should take into account all the factors relevant to site formation, in particular the existence of favourable depositional conditions only during short time spans, the Quaternary landscape evolution characterised by several intertwined cycles of erosion and sedimentation, and the spatial distribution of stratigraphies containing remains and their apparently similar empty counterparts.

1. Spatial Distribution of the Sites

The aim of the present contribution is to offer a general overview of the distribution of the Lower Palaeolithic sites - with both bones and artefacts- of the surroundings of Rome (Fig. 1), moreover to trace some regularities in their spatial distribution and to analyse some of the factors that may have played a role in their preservation and discovery. Geological characteristics and discovery conditions of 12 major sites are given in table I (a, b).

According to the site distribution in relation to the geological context, the older sites (age about 300,000 years) are predominantly related to the fluvio-lacustrine environment existing towards the end of the main volcanic activity of the Albano and Sabatino districts (Middle Pleistocene, between about 500,000 and 300,000 years BP). Instead, the younger sites (age 200,000 - 125,000 years) are related predominantly to a plainly alluvial environment. In the older group, present altitudes are higher than in the younger group (60 to 70 m a.s.l. – with Torre in Pietra "m" as an exception - versus 30 to 50 m a.s.l.). One notices that half of the sites were discovered after 1970 (mainly those belonging to the older group).

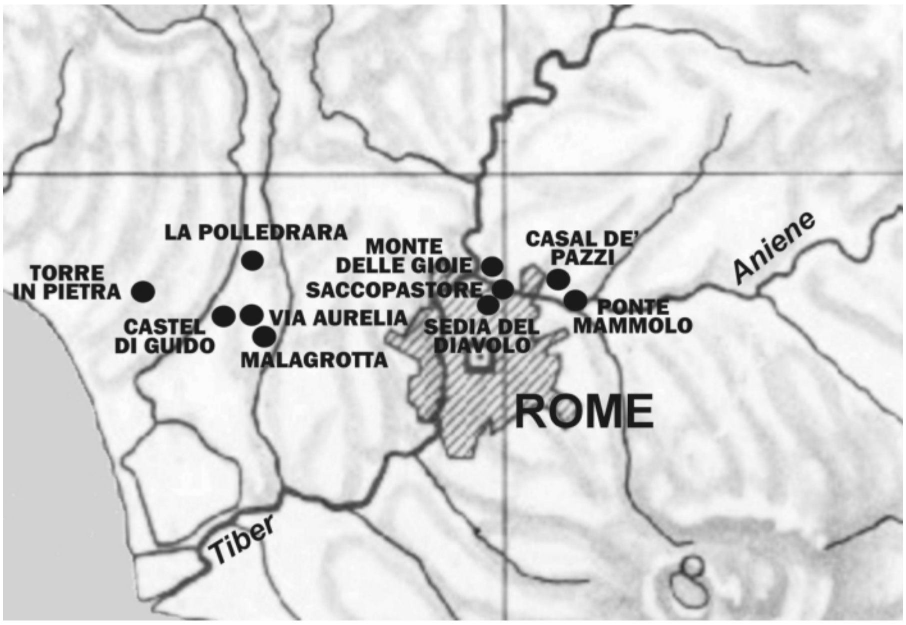

Fig.1 - Distribution of the major Lower Paleolithic sites around Rome.

2. A CONDITION FOR SITE-FORMATION: EMBEDDING IN SEDIMENTS

An essential site forming condition is the formation of the embedding sediment. From the viewpoint of landscape development, to survive in time, the remains should be embedded in the most recent cycle of deposition, or in relicts from older cycles that escaped later erosion. Moreover, the deposit should be located in such a position in the present landscape that the depth below the surface allows for discovery (Arnoldus-Huyzendveld 1995).

The sediments of the Middle Pleistocene (middle and late) of the "Bassa Campagna Romana", represented by the alluvial sediments of the Tiber river and its complex tributary system, are clearly related to the eustatic rise of the sea level at the moment of deglaciation and represent complete sedimentary cycles (Malatesta & Zarlenga 1986, 1986a, 1988). Their position, at least concerning the three oldest cycles (formations of San Cosimato, Aurelia and Vitinia; Conato *et al.* 1980), did not give rise to alluvial terraces in the stricter sense, since no uplift phases occurred during their deposition. Being the later fills inset in the trenches cut in the earlier fills, these sediments can be identified as "alluvial fills inset" (Leopold *et al.* 1964). They are separated by erosion surfaces of global character, related to the eustatic lowering of the sea level in coincidence with glacial phases (Caloi *et al.* 1998).

Examining the most recent sedimentary cycle, represented by the present Tiber floodplain deposits, with a thickness variable between 100 m near the sea and about 50-60 m near the city of Rome, we observe that these layers were deposited between 12000 and 8000 years ago. This means that an alluvial infill was produced in only 4000 years; this value can be enlarged when admitting a reasonable margin of error, but anyway a very short time stands out.

Reflecting upon the fact that, in the past, alluvial infills of this type have been considered to coincide with the entire interglacial part of a glacial-interglacial cycle (the whole cycle lasting on average about 100,000 years), one notices that from the record of the interglacial phase a large part of possible information contained within the sediments is lacking. Therefore, a fluvial sedimentary cycle in areas close to the river outlet, like the "Bassa Campagna Romana", does not represent else then a small part of a much longer story.

Tab.1a - Discovery- and site characteristics of the principal Lower Palaeolithic sites around Rome.

Site	Altitude m. a.s.l.	Year of discovery	Conditions of discovery	Motive of discovery	Period excavation / study	Geological formation	Isotopic stage	Geological facies
Torre in Pietra "d"	44	1954	quarry outcrop	survey	1954-1964	Vitinia formation	7	alluvial
La Polledrara di Cecanibbio	83	1984	surface outcrop	systematic survey	1985-2001	Aurelia formation	9	fluvio-lacustrine
Castel di Guido	71	1970	quarry outcrop	survey	1980-1990	Aurelia formation	9	fluvio-lacustrine
Casal de' Pazzi - Rebibbia	28	1981	road enlargement	public works	1981-1986	Aniene middle terrace	7	alluvial
Sedia del Diavolo	44	1882	roadside outcrop	quarry	1935-1938	Aniene middle terrace	7	alluvial
Monte delle Gioie	49	1869	surface outcrop	quarry and railroad construction	1938	Aniene middle terrace	7	alluvial
Saccopastore	23	1929	surface outcrop	quarry	1935	Aniene lower terrace	5e	alluvial
Ponte Mammolo	30	1837	surface outcrop	survey	1866-1867	Aniene middle terrace	7	alluvial
Malagrotta	57	1970	surface outcrop	survey	1975-1978	Aurelia formation	9	fluvio-lacustrine
Torre in Pietra "m"	34	1954	surface outcrop	survey	1954-1964	Aurelia formation	9	alluvial
Via Aurelia km 19.3	60	1970	roadside outcrop	survey	1981-1984	Aurelia formation	9	fluvio-lacustrine
Via Aurelia km 18.9	65	1990	surface outcrop	survey / public works	1990	Aurelia formation	9	fluvio-lacustrine

Tab.1b - Discovery and site characteristics of the principal Lower Palaeolithic sites around Rome (continued)

Site	Stratigraphy	Present landform	Paleo-environment	Burying layers	Fossilisation process	Bone preservation
Torre in Pietra "d"	sandy-gravelly river infill	hill slope / terrace	river channel	alluvial deposits	probably calcification	various
La Polledrara di Cecanibbio	clayey tufitic sediments	hill slope	fluvio-lacustrine basin / ephemeral river channel	fluvio-lacustrine and pyroclastic deposits	fluoritisation	excellent
Castel di Guido	clayey tufitic sediments	hill summit	fluvio-lacustrine basin / ephemeral river channel	fluvio-lacustrine deposits	probably fluoritisation	good
Casal de' Pazzi - Rebibbia	sandy-gravelly river infill overlying "tufo lionato"	terrace	main river channel	alluvial deposits	probably calcification	various
Sedia del Diavolo	sandy-gravelly river infill	terrace	main river channel	fluvio-lacustrine and pyroclastic deposits	probably calcification	various
Monte delle Gioie	sandy-gravelly river infill	terrace	main river channel	fluvio-lacustrine and pyroclastic deposits	probably calcification	various
Saccopastore	sandy-gravelly river infill	terrace	main river channel	alluvial deposits	probably calcification	various
Ponte Mammolo	sandy-gravelly river infill overlying "tufo lionato"	valley side, terrace	main river channel	alluvial deposits	probably calcification	various
Malagrotta	clayey tufitic sediments	hill slope	fluvio-lacustrine basin	fluvio-lacustrine deposits	probably calcification	various
Torre in Pietra "m"	erosion surface	hill slope / terrace	land surface	alluvial and fluvio-lacustrine deposits	probably calcification	various
Via Aurelia km 19.3	clayey and sandy tufitic sediments	hill slope	fluvio-lacustrine basin / ephemeral river channel	fluvio-lacustrine deposits	probably fluoritisation	good
Via Aurelia km 18.9	clayey and sandy tufitic sediments	hill slope	fluvio-lacustrine basin / land surface	fluvio-lacustrine and pyroclastic deposits	probably fluoritisation	good

And moreover, that part is limited to interglacial climatic conditions, since the eventually existing remains refering to glacial periods are now covered by the sea.

There occur also sediments, mainly lacustrine, but also alluvial, e.g. alluvial flooding deposits, which are detached from this specific evolutionary context, i.e. detached from the outcrops of the "alluvial fill inset", and for which it has been possible to reconstruct a detailed evolution. Frequently, just in these contexts paleontological and palethnological differences of a certain extent are observed, and sensible differences between the industries of various outcrops or differences in the faunas are evaluated. Here the request arises to refine the geological time scale. But from the geological viewpoint it is not possible to define a different reference period since the event is the same, i.e. the rising and highstand of the sea level, and almost never one succeeds in understanding the exact point on the time line of the events.

A particular limitation of the "Campagna Romana" is moreover the absence of limestone outcrops and the consequential lack of caves with archaeological and faunal remains.

Volcanic layers represent precious markers for the regional stratigraphical reconstruction, but neither the volcanic activity of the Albano and Sabatino districts has been continuous (De Rita *et al.* 1991; 1993; De Rita & Zarlenga, this volume). The activity started about 500,000 years ago and lasted until about 25,000 years ago, with very long periods of inactivity. Therefore, also the information contained in volcanic products, or in the sediments derived from them, are limited to precise moments of the regional evolution. For instance, one should consider (De Rita *et al.* 1993) that the major part of the activity and the products of the "Tuscolano-Artemisio" period of the Albano volcanic district seems to be deposited during phases of low sea level.

One must conclude that the information contained in sediments, and thus it paleontological and palethnological content, does not evidence anything else than particular moments of much longer lasting geological events, about which we have no, or very few, information. Certainly, once cleared up this limitation of geology it is possible, by integrating the various information, to succeed more or less correctly in determining the point on the time line of a specific site.

3. Other Conditions for Site Formation

3.1 Favourable living conditions

We may presume that the peculiar environmental conditions of the Rome area, surrounded by volcanoes that were during the Lower Palaeolithic in their "afterlife", must have exercised a general attraction on the mammal fauna. One could mention the abundant vegetation on fertile soils, the abundance of springs and water courses, the complex pattern of environmental conditions, the ease of tracking from one area to another caused by the levelling effect of the pyroclastic deposits – absence of steeply dissected valleys-, the presumable dominance of intermittent parallel river channels (of the "braided" type) related to the high sediment load of the water courses, and the frequent occurrence of stagnant waters so typically for a "young" geomorphology.

3.2 Burial and fossilisation

Taphonomy analysis provide a convenient tool to detect how fossils form and why they are found where they are (Andrews 1997; AA.VV. 1999; Martin 1999). As already known, the possibility to have bone–bearing deposits depend on nature of the organism, way and place of life and manner and cause of death, nature of biotic and physical processes operating during transport, burial and fossilisation, nature of deposit, processes of accumulation and of diagenesis of remains. Consequently, the bone-bearing deposit formation is not an usual phenomenon and a bone record rarely samples more than a very small and more or less poorly representative selection of an animal community (Behrensmeyer 1991). Any way, bones, made by complex matrix of proteinaceous materials (collagen and others), highly mineralised and reinforced with hydroxyapatite ($Ca_{10}[PO_4]_6[OH]_2$) are usually the last part of the vertebrate body to decompose and are often robust enough to survive and fossilise. Preservation is aided by the relative resilience of bone, which provides improved opportunities for chemical alteration and fossilisation (Trueman & Benton 1997). However, bones are subject to destruction through breakage due to transport, trampling, scavenging, digestive process, weathering, wetting and drying, acid conditions etc.

Rapid burial is a near essential for bone preservation. This is usually accomplished in fluvial, lacustrine or marine environments though there can preservation in terrestrial sites under suitable chemical conditions. Caves, ash originating from volcanic eruptions and vulcanoclastic deposits can also offer conditions in order to a potential preservation. Fluvial conditions notably affect by selective transport the composition of bone-bearing. In fact, the transport of bone to sites of deposition are governed by the same rules which control movement of other sedimentary particles. In many instances, bone beds develop on river bends or other sites where clasts accumulate. This is the pattern of many deposits of the “Campagna Romana”.

In the “Campagna Romana”, bone fossilisation has presumably occurred in most cases through calcification. Although few analysis on the chemical composition of the bones are published, one could infer this from the composition of the circulating groundwater, which is frequently calcareous through the influence of the sandy calcareous layers interbedded between the clayey Pliocene substrate and the volcanic deposits.

A special case of fossilisation is present at the La Polledrara site, i.e. evidently through fluoritisation (Arnoldus-Huyzendveld & Anzidei 1993; Anzidei *et al*. in press). The composition of the bones has been determined by diffractometric analysis as fluoroapatite, a resistant and hard material. The bone remains are frequently associated with small fluoritic aggregates and more rarely, with large imprints of radial gypsum crystals. The local lacustrine sediments are made up mainly of ashy tuffites. Within these sediments there occur occasionally whitish layers, composed mainly of fluorite (also barite and halite are present as minerals).

The origin of these layers has been related to the rise along fractures of mineralised fluids causing fumaroles at the surface. Volcanic gas may mix with ash, and fluorine may link to the ash particles. The process of fossilisation may have occurred by indirect contact of the bones with ashes and fluorine-containing water. The chemical transformation must have been of this type: hydroxyapatite + F <—> fluoroapatite + OH. The gypsum ($CaSO_4$) could be a result of the interaction of the bone calcium with the sulphur contained in the fluids or gasses.

The distribution of fluorite layers in the local geological context turned out to be limited to a narrow N-S belt with a length of more than 10 km, crossing the site. Therefore, this kind of fossilisation may have occurred as well in other sites situated on this belt (Castel di Guido, Via Aurelia, Boschian 1993). The fluorite deposits of the Rome area are a rather rare phenomenon if seen on a world scale, so probably also this way of bone fossilisation.

3.3 Discovery of the sites

Urban or suburban conditions do evidently contribute to the discovery of archaeological sites. The discovery conditions of the sites of the “Campagna Romana” were essentially of two kinds: or in relation to intensive surface transformation through quarries or public works or to more or less systematic surveys. The two types of discovery tend to concentrate in two different sectors of Rome: the former in the north-eastern area (Casal de' Pazzi, Sedia del Diavolo, Monte delle Gioie, Saccopastore, Ponte Mammolo) and the latter in the area to the west of the town, close to the Via Aurelia (Torre in Pietra, Castel di Guido, Malagrotta, La Polledrara di Cecanibbio, Via Aurelia km. 19,3). This distribution is related to the recent development of these areas. From the end of the 19th century on, the eastern zone has been subject to urbanisation, with the gradual substitution of the existing gravel and sand quarries by urban quarters. On the contrary, a vast area to the west was composed by large estates belonging to the "Pio Istituto di S. Spirito" and the "Ospedali Riuniti di Roma", which were used as agricultural estates and farms for supplying the Roman hospitals. These properties passed in 1978 to the Rome Municipality and were from then on protected by the Urban Development Plan, thus maintaining their agricultural vocation.

Another aspect typical of the Rome area is the presence of many Institutions related to the archaeological heritage. We should mention research Institutes like the "Istituto Italiano di Paleontologia Umana", the University of Pisa and particularly the survey activity and capillary archaeological research and protection activity of the Rome territory by the "Soprintendenza Archeologica" of Rome. So it has been possible to exercise a control on the territory and to verify constantly the stratigraphical situations and the archaeological presences put to light during the expansion of the city. The result of this policy has been the identification, excavation and preservation, of two of the most interesting late Middle Pleistocene deposits in Italy: the La Polledrara and the Casal de' Pazzi sites, as well as the acquisition of many data useful for a detailed geomorphological and palaeo-environmental reconstruction of the Rome territory.

4. CONCLUSIONS

Referring to the present distribution of the early Palaeolithic sites in the Rome territory, one notices that a few stratigraphical situations are dominant, i.e. alluvial and volcanic-lacustrine.

From the geological considerations exposed it follows that sedimentary conditions must have dominated only during a small portion of time, i.e. the phase of sea level rising. Moreover, natural caves that eventual could fill some of the gaps in our knowledge are lacking in the "Campagna Romana". And finally, the known data are limited to interglacial climatic conditions, since the eventually existing remains refering to the glacial periods are now covered by the sea or have been removed by surface erosione. Considering moreover the other conditions necessary for becoming a site (frequentation, burial, fossilisation and discovery), it may be justified to conclude that the present distribution of Lower Palaeolithic sites near Rome is probably due mainly to fortunate sequences of events related to the local and regional geological and morphological evolution. In particular one could refer to the conditions that the top of the volcanic-lacustrine sediment layers (with locally favourable fossilisation conditions for the faunal remains) became exposed through the late Pleistocene and Holocene surface erosion, and that in the lower tract of the Aniene River, the terraces were locally well preserved trough the combined influence of lateral river displacement (sea level highstand) and linear dissection (last sealevel lowstand).

It must be stressed that, due to the intensive urbanisation and the constant presence of the institutions, in the "Campagna romana" many potential "containers" have been observed, i.e. those stratigraphies that may have had the potential to embed and preserve the paleontological and associated archaeological remains. But almost never these turned out to be present.

Taking into account the existence of favourable local depositional conditions only during short time spans and the (complementary) huge gaps in time and space, moreover a Quaternary landscape evolution characterised by several intertwined cycles of erosion and sedimentation, and finally the spatial distribution of "empty" stratigraphies and of stratigraphies containing remains, it should well be possible to gain insight into the real areas of frequentation.

5. REFERENCES

AA.VV. 1984. I primi abitanti d'Europa. 1.500.000 – 100.000 anni. *Catalogo della mostra. Ministero per i beni culturali e ambientali, Soprintendenza speciale al museo preistorico etnografico "Luigi Pigorini"*. Roma: De Luca.

AA.VV. 1999. Taphonomy as a tool in palaeoenvironmental researches and environmental assessment. *Palaeogeography, Palaeoclimatology, Paleoecology*, 49, special issue.

Andrews, P. 1997. What Taphonomy can and cannot tell us. *Quadernos de Geologia Iberica* 23: 53-72.

Anzidei, A.P., Angelelli, F., Arnoldus-Huyzendveld, A., Caloi, L., Palombo, M.P. & Segre, A.G., 1989. Le gisement Pleistocène de la Polledrara di Cecanibbio (Rome, Italie). *L'Anthropologie*, XCIII, 3: 749-781.

Anzidei, A.P. & Arnoldus-Huyzendveld, A., 1992. The middle Pleistocene site of La Polledrara di Cecanibbio (Rome, Italy). *Fourth Conference of Italian Archaeology, B.A.R., I.S.*: 141-153.

Anzidei, A.P., Arnoldus-Huyzendveld, A., Lemorini, L., Caloi L. & Palombo, M.R. 1999. Two Middle Pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia - Casal Dè Pazzi; The role of early humans in the accumulation of European lower and middle Palaeolithic bone assemblages. *Atti del Convegno tenutosi a Mainz, 1995*: 173-195.

Anzidei, A.P., Cassoli, P.F., Ruffo, M. and Segre A.G., 1984. Risultati preliminari dello scavo di un deposito pleistocenico in località Rebibbia-Casal de’ Pazzi. *Atti del XXIV Convegno dell’Istituto Italiano di Preistoria e Protostoria.*

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Mussi, M. & Palombo, M.R. in press. Nouvelles Données sur le gisement Pleistocène moyen de La Polledrara di Cecanibbio (Latium, Italie). *Actes du Colloque International de Tautavel sur "Les Premiers habitants de l'Europe" (10-15 avril 2000).*

Anzidei, A.P. & Gioia, P. 1990. The lithic industry from Rebibbia-Casal de' Pazzi. In *Paper of the Fourth Conference of Italian Archaeology, New Developments in Italian Archaeology* Part 1: 155-179.

Anzidei, A.P. & Ruffo, M.. 1985. The Pleistocene deposit of Rebibbia-Casal de' Pazzi (Rome, Italy). *Papers in Italian Archaeology IV - Part I. The Human Landscape. Bar International Series* 243: 69-85. Oxford.

Arnoldus Huyzendveld, A. & Anzidei, A.P. 1993. Ricostruzione di un ambiente fluviolacustre nella regione vulcanica di Roma (La Polledrara di Cecanibbio). *Atti XXX Riunione Scientifica Istituto Italiano di Preistoria e Protostoria (Firenze 1993)*: 151-165.

Arnoldus-Huyzendveld, A. 1995. The passage of information from the socio-cultural to the archaeological context; aspects of applied soil science and sedimentology. In P. Urbanczyk (ed.), *Theory and Practice of Archaeology, part II: Acquisition of field data at multi-strata sites*: 25-68. Warszawa.

Behrensmeyer, A.K. 1991. Terrestrial Vertebrate Accumulations. In Allison, P.A. & Briggs, D.E.G., *Taphonomy*, 6: 291-335.

Bietti-Sestieri, A.M. (ed.) 1984. Preistoria e Protostoria nel territorio di Roma. *Lavori e studi di archeologia pubblicati dalla Soprintendenza archeologica di Roma*. Roma: De Luca.

Boschian, G. 1993. Castel Di Guido, scavi 1980-1991. In *Paleosuperfici del Pleistocene e del primo Olocene in: Italia, processi di formazione e interpretazione. Istituto Italiano di Preistoria e Protostoria, Atti della XXX riunione scientifica*: 167-178.

Caloi, L., Palombo, M.R. & Zarlenga, F. 1998. Late Middle Pleistocene mammal faunas of Latium (Central Italy): Stratigraphy and environment. *Quaternary International Journ.* 47-48: 77-86.

Cassoli, P.F., De Giuli, C., Radmilli, A.M., Segre, A.G. 1982. Giacimento del Paleolitico Inferiore a Malagrotta (Roma). In *Istituto Italiano di Preistoria e Protostoria, Atti della XXIII riunione scientifica*: 531-535.

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

De Rita, D., Milli, S., Rosa, C. & Zarlenga, F. 1991. Un'ipotesi di correlazione tra la sedimentazione lungo la costa tirrenica della campagna romana e l'attività vulcanica dei

Colli Albani. *Studi Geol. Camerti, Vol. Spec.: "Studi preliminari all'acquisizione dati del profilo CROP 11. Civitavecchia-Vasto"*: 343-349.

De Rita, D., Milli, S., Rosa, C., Zarlenga, F. & Cavinato, G.P. 1993. Catastrophic eruptions and glacioeustatic episodes in Latium. *International Conference: "Large explosive eruptions". Accademia Nazionale dei Lincei 25/5/93, Rome*.

Leopold, L.B., Wollman, M.G. & Miller, J.P. 1964. *Fluvial processes in geomorphology*. San Francisco and London: Freeman W.H. & Company.

Malatesta, A. 1978. Torre in Pietra. Roma. *Quaternaria* 20: 203-577.

Malatesta, A. & Zarlenga, F. 1986. Evoluzione paleogeografico- strutturale plio-pleistocenica del basso bacino romano a Nord e a Sud del Tevere. *Memorie della Società Geologica Italiana*, 35: 75-85.

Malatesta, A. & Zarlenga, F. 1986a. Cicli trasgressivi medio pleistocenici sulle coste liguri e tirreniche. *Geologica Romana* 25. 1-8.

Malatesta, A. & Zarlenga, F. 1988. Evidence of Middle Pleistocene marine transgressions along the Mediterranean coast. *Palaeogeography, Palaeoclimatology, Palaeoecology* 68: 311-315.

Martin, R.E. 1999. Taphonomy: a process approch. *Cambridge Palaebiology series* 4, Library accession 560.

Radmilli, A.M. & Boschian, G. 1996. *Gli scavi di Castel di Guido. Il più antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano*. Firenze: Istituto Italiano di preistoria e Protostoria.

Taschini, M. 1967. Il "Protopontiniano" rissiano di Sedia del Diavolo e di Monte delle Gioie (Roma). *Quaternaria* IX: 301-319.

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Update Middle Pleistocene fossil birds data from Quartaccio quarry (Vitinia, Roma, Italy)

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SUMMARY: The Middle Pleistocene fossil birds from the Vitina Formation (Quartaccio quarry, Vitinia, Roma) have been revised and 12 taxa have been identified: *Podiceps grisegena, Ardea purpurea, Anser* sp., *Branta ruficollis, Anas platyrhinchos, Anas clypeata, Somateria mollissima, Mergus serrator, Fulica atra, Gallinago* sp., *Sturnus vulgaris, Pyrrhula pyrrhula*. This revision of the fossil material allows to modify the faunal list pointed out in previous works: for example, the occurrence at Quartaccio quarry of *Branta ruficollis, Anas clypeata, Somateria mollissima, Mergus serrator, Sturnus vulgaris, Pyrrhula pyrrhula* have been checked while the occurrence of *Podiceps cristatus, Anser* cfr. *albifrons, Anser* cfr. *erythropus, Anser* cfr. *fabalis, Anas penelope, Aythya ferina, Turdus iliacus, Carduelis chloris* cannot be confirmed.

1. INTRODUCTION

The fossil birds assemblage from Quartaccio quarry (Vitinia, Roma) (Fig. 1) have been taken into account in order to update the systematic of the avifauna.

The sediments outcrop in the Quartaccio quarry can be divided into 4 Formations: Ponte Galeria Fm., San Cosimato Fm., Aurelia Fm. and Vitinia Fm. The Pleistocene deposits and the vertebrate remains coming from the Vitinia Formation have been studied by several authors (Conato *et al.* 1980, Caloi *et al.* 1983, 1998). In particular, the vertebrate fauna, including the

Fig.1 - Location of Quartaccio quarry (Vitinia, Roma).

bird bones, come from reddish-brown lacustrine clays, interbedded by cross stratified sands and tufitic levels (Level e2) (Fig. 2). The faunal association includes: Ciprinidae, Esocidae, *Rana* sp., *Bufo viridis*, *Emys orbicularis*, *Testudo hermanni*, *Podiceps cristatus*, *Anser* cfr. *albifrons*, *Anser* cfr. *erythropus*, *Anser* cfr. *fabalis*, *Anas platyrhinchos*, *Anas penelope*, *Aythya ferina*, *Fulica atra*, *Gallinago gallinago*, *Turdus iliacus*, *Carduelis chloris*, *Arvicola* sp., *Canis lupus*, *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus hemitoechus*, *Dama dama tiberina*, *Cervus elaphus*, *Bos primigenius* (Caloi *et al.* 1983, 1998; Di Stefano & Petronio 1997). The faunal assemblage can be referred to the Middle Pleistocene Vitinia Faunal Unit (Gliozzi *et al.* 1997).

2. SYSTEMATIC

The revision of the fossil material allows to identify the following taxa:

Order Podicipediformes
Family Podicipidae
Podiceps grisegena (Boddaert 1783)
Order Ciconiformes
Family Ardeidae
Ardea purpurea Linnaeus, 1766
Order Anseriformes
Family Anatidae
Anser sp.
Branta ruficollis (Pallas 1769)
Anas platyrhinchos Linnaeus, 1758
Anas clypeata Linnaeus, 1758
Somateria mollissima Linnaeus, 1758
Mergus serrator Linnaeus, 1758
Order Gruiformes
Family Rallidae
Fulica atra Linnaeus, 1758
Order Charadriiformes
Family Scolopacidae
Gallinago sp.
Order Passeriformes
Family Sturnidae
Sturnus vulgaris Linnaeus, 1758
Family Fringillidae
Pyrrhula pyrrhula (Linnaeus 1758)

Order Podicipediformes
Family Podicipidae
Podiceps grisegena
1 femur

This bone have been compared with those of *Podiceps grisegena* and *Podiceps cristatus*. The two species differs in the shape of impressions of the *crista femoralis*; the first species shows an irregular impression, nearer to the crista than

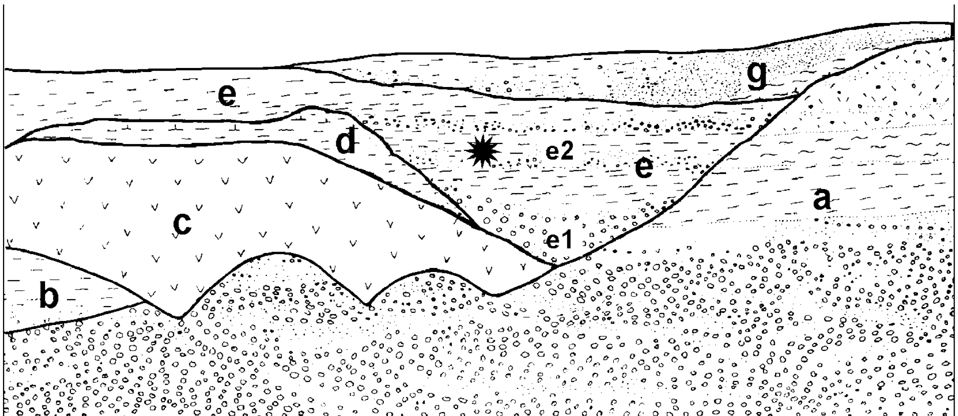

Fig.2 - Stratigraphical sketch of Quartaccio quarry (Vitinia, Roma): a) Ponte Galeria Formation; b) S. Cosimato Formation; c) “Tufo litoide lionato”; d) Aurelia Formation; e) Vitinia Formation: e$_1$ cross bedded gravels and sands, e$_2$ reddish-brown lacustrine clays, interbedded by cross stratified sands and tufitic levels (Modified from Caloi *et al.* 1983). * Fossiliferous level.

in *P. cristatus*, which has a more regular impression; besides, *P. grisigena* in the proximal part has a longer and higher line. This characteristic allows to separate *P. grisegena* from *P. cristatus*, as also pointed out by Bochenski (1994).

Ordine Ciconoformes
Family Ardeidae
Ardea purpurea
1 femur

The features of this bone are typical of the family Ardeidae; the size of the specimen considered is near to *Ardea purpurea* and *Casmerodius albus*. The distal part is thin and long and the *facies articularis acetabularis* is small and thin; the crista trochanteris is prominent. These morphological characteristics are typical of *Ardea purpurea*.

Ordine Anseriformes
Family Anatidae
Branta ruficollis
1 humerus

This bone is fragmentary, but its features is comparable with two genera *Branta* and *Anser*. The impressio muscoli inferioris is slightly deep and this is a typical features of genere *Branta*; for its size the specimen can be referred to *Branta ruficollis*.

Anas platyrhinchos
1 coracoid, 1 humerus

This duck is represented by a distal part of a humerus and a coracoid. The humerus has features that can be recognised in to two different species, *Tadorna tadorna* and *Anas platyrhinchos*; the impression in the fossa brachialis is curved and thin and the *epicondylus ventralis* has regular lips. In the coracoid the facies articularis humeralis is circular and the *cotyla scapolaris* has regular lips. The central part of the bone is slender and thin. The facies articularis sternalis is high and slightly deep. These features allow to refer these bones to *A. platyrhinchos.*

Anas clypeata
1 carpometacarpus, 1 ulna

These bones show a morphology very similar to the living species *Anas clypeata*. The carpomeatcarpus has a prossimal part characterised by a *processus extensorius* and a *processus pisiformis* less prominent than in the *Anas penelope*, which has approximately the same size. In the distal part, the *os carpalis minus* is more prominent than the *os carpalis majus* and the intersection between these is prominent too. In the ulna the *facies articularis* is lowered and the olecranon is shifted toward the external side.

Somateria mollissima
1 ulna

The features of the *impressio brachialis* of this ulna is in agreement with the genus *Somateria*. The size is near to *Somateria mollissima*.

Mergus serrator
1 humerus

This bone is characterised by a long body and a thin epiphysis like in the genus *Mergus*. The size is near the range of the species *Mergus serrator*, smaller than *M. merganser* and bigger than *M. albellus*.

Ordine Gruiformes
Family Rallidae
Fulica atra
1 femur, 1 tarsometatarsus

The features of these bones are near to those of the living *Fulica atra*. The proximal part of the femur is characterised by a prominent *crista trochanteris*. The tarsometatarsus shows a *cotyla medialis* with a circular lips, a typical oblique line links the epiphisis to the central part of the diaphisys. In the distal part the *fossa metatarsi* I is quite shallow .

Gallinago sp.
1 ulna

The genus *Gallinago* is characterised by an ulna with *cotyla dorsalis* more expanded and prominent than in the genera *Tringa* and *Calidris*, the closest forms for morphological features. Moreover there is a impression which is absent in the other two genera. The olecranon is high in the posterior part. The genus *Gallinago* includes two species, *G. gallinago* and *G. media*; a more detailed taxonomical analysis is still in progress.

Order Passeriformes
Family Sturnidae
Sturnus vulgaris
1 humerus, 2 carpometacarpi, 1 tibiotarsus

In its proximal end, the humerus shows two hollows separated by a median bar; this feature is typical of two genera, *Sturnus* and *Pinicola* (Janossy 1983). This bone has morphological features close to those of *Sturnus*, with a thin epiphisis and a very prominent *caput humeri*. The genus *Sturnus* includes two species differing mainly for their size: *S. vulgaris* showing an epiphysis larger than the second species, *S. roseus*. In the carpometacarpus the *processus extensorius* is less prominent than in the similar genus Turdus, while the *fovea caudalis* is more prominent. The *os carpalis minus* is slightly curved and parallel to the os carpalis majus. In the distal part, the *sulcus interossos* is shallow. The tibiotarsus is characterised by an *area interarticularis* very marked and a *crista patellaris* with no introflexion. The distal epiphysis is small and of regular shape.

Family Fringillidae
Pyrrhula pyrrhula
1 humerus

The small size of this bone (smaller than 20 mm) and the presence of two deep hollows are typical of the family Fringillidae. The features is near to genus *Pyrrula*, which differs from the other taxa of Fringillidae in having a median bar shifted toward the frontal side of the bone and wider (Janossy 1983).

3. Conclusions

The systematic analysis has detected the occurence of 12 taxa belonging to 11 genera. Respect the list presented in previous works (Caloi *et al.* 1983, 1998) the revised faunal list differs in some elements: *Podiceps grisegena, Branta ruficollis, Anas clypeata, Somateria mollissima, Mergus serrator, Pyrrhula pyrrhula, Sturnus vulgaris* have not been checked before; on the contrary the occurrence of *Podiceps cristatus, Anser* cfr. *A. albifrons, Anser* cfr. A. *erythropus, Anser* cfr. *A. fabalis, Anas penelope, Aythya ferina, Turdus iliacus, Carduelis chloris* is not confirmed.

The avifauna of Quartaccio quarry includes uncommon taxa for the Pleistocene deposits. For example the remain of *Somateria mollissima* represents the oldest record of the species and the first for Italian deposits (Tyrberg 1998). Moreover, *Podiceps* aff. *P. grisegena* was found in Italy previously only in the Late Pleistocene deposit of Colombi Cave (Liguria) (Tyrberg 1998) and the specimen from the Vitinia Formation can be considered the first occurrence of this species until now.

Taking into account the revised data, updated palaeoecological considerations on the Vitinia avifauna can be pointed out. Almost all the represented taxa can be related with humid palaeoenvironmental conditions. Moreover, the occurrence of *Pyrrhula pyrrhula*, a short range migrant, is linked to the presence of forests (Cramp & Perrins 1994), probably covering the slopes of the basin.

4. Acknowledgments

I wish to thank Marco Pavia, Raffaele Sardella and Maria Rita Palombo for their useful suggestions and the Dipartimento di Scienze della Terra, Università degli Studi di Torino for the hospitality during the study of the material.

5. References

Bochenski, Z. 1994. The comparatrive osteology of grebes (Aves: Podicipediformes) and its systematic implications. *Acta Zoologica Cracoviense* 37: 191-346.

Caloi, L., Cuggiani, M.C., Palmarelli, A. & Palombo, M.R. 1983. La fauna a vertebrati del Pleistocene medio e superiore di Vitinia. *Bollettino del Servizio Geologico d'Italia* CII: 41-76.

Caloi, L. Palombo, M.R. & Zarlenga, F. 1998. Late-Middle Pleistocene mammals faunas of Latium (Central Italy): stratigraphy and enviroment. *Quaternary International* 47/48: 77-86

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

Cramp, S. & Perrins, C.M. (eds.) 1994. *The birds of the Western Palearctic*. vol. VIII: 488 pp. Oxford: Oxford University Press.

Di Stefano, G. & Petronio, C. 1997. Origin and evolution of the European fallow deer (Dama, Pleistocene). *N. Jb. Geol. Paläont. Abh.* 203(1): 57-75

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 in Italy. The state of the art. *Rivista Italiana di Paleontologia e stratigrafia* 103 (3): 369-388.

Janossy D. 1983. Humeri of Central European smaller Passeriformes. *Fragmenta Mineralogica et Paleontologica*, 11: 85-112.

Tyrberg, T. 1998. Pleistocene birds of Paleartic: a Catalogue. *Pubblication of the Nuttal Ornithological Club* 27: 720 pp.

La tecnica di scheggiatura bipolare applicata ai ciottoli

- Considerazioni su un lavoro di scheggiatura sperimentale

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SUMMARY: Bipolar flaking technique has been extensively used in coastal Latium all over the Palaeolithic to split the locally available small-sized flint and chert pebbles. Experimentation has been carried out, following two different procedures: 1) selecting a pebble of suitable size, shape and quality, to produce a specifically planned tool; 2) making a tool from a flake found suitable, but produced during an otherwise unplanned knapping episode. The selection of both the striking pebble, and the anvil, was found to be related to personal choice, strength and size of the hand. Scars and patterns which are diagnostic of bipolar flaking technique have been identified.

1. INTRODUZIONE

Scopo del lavoro di sperimentazione è stato quello di comprendere i meccanismi di produzione dei manufatti scheggiati rinvenuti in alcuni contesti archeologici, la cui particolarità è quella di essere stati prodotti a partire da ciottoli di dimensioni ridotte, situazione tipica della maggior parte dei siti del Lazio costiero nella preistoria.

La sperimentazione è stata condotta su un campione di 90 ciottoli, provenienti da sei diversi affioramenti naturali (Ponte Galeria, Campo Iemini, Cava Esin, Cava della Romana Calcestruzzi, Marina di S. Nicola, Casal de'Pazzi), la cui lunghezza, ovvero la dimensione maggiore varia da 27 mm a circa 80 mm. Questo campione corrisponde al tipo di materiale siliceo disponibile durante il Pleistocene Medio e Superiore nell'area di Roma. La tecnica che è stata utilizzata per lavorare questi ciottoli di piccole dimensioni è quella della scheggiatura bipolare, che consiste nel colpire con un percussore il ciottolo poggiato su un incudine (Laj Pannocchia 1950).

Riteniamo che, a livello archeologico, ci sia stato un condizionamento ambientale, che ha determinato da una parte l'utilizzo obbligato del materiale a disposizione, e dall'altra l'adozione di questa particolare tecnica di scheggiatura, dal momento che è oggettivamente difficile e scarsamente efficace scheggiare un piccolo ciottolo tenendolo in mano.

Il 50% delle percussioni è stato effettuato lungo l'asse della lunghezza, il 30% lungo quello dello spessore ed infine il 20% per quello della larghezza.

2. LA SPERIMENTAZIONE: CONSIDERAZIONI

2.1 Progettualità

In questa parte del lavoro si cercherà di formalizzare i passi decisionali che dalla scelta del ciottolo conducono alla percussione dello stesso.

2.1.1 Scelta del ciottolo

Gli elementi che determinano la scelta del ciottolo possono essere schematizzati come segue:

- necessità da soddisfare (tipo di strumento che si desidera ottenere)
- forma del ciottolo
- qualità apparente della materia prima

Intorno a queste tre variabili si delineano due principali orientamenti di scelta:

a) Scelta orientata da un'idea di strumento: qualora si abbia in mente uno scopo preciso, la scelta si fonda sulla selezione dei ciottoli che presentino caratteristiche morfologiche adeguate.

(Esempio: allo scopo di produrre un oggetto laminare si cercheranno ciottoli di forma allungata).

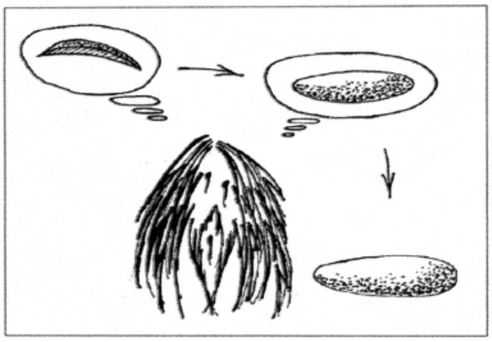

Fig.1 - Scelta orientata da una specifica idea di strumento.

b) Scelta non orientata da un'idea di strumento: qualora non vi sia un progetto prestabilito è la forma che suggerisce l'idea di uno strumento.

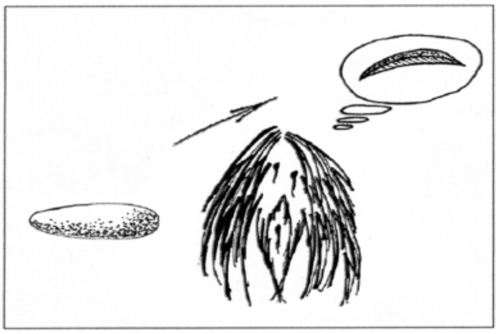

Fig.2 - Scelta non orientata da una specifica idea di strumento.

In entrambi i casi la scelta finale avviene in base alla qualità della materia, com'è suggerita dalla vista e dal tatto.

Un ulteriore elemento di selezione del ciottolo riguarda situazioni in cui siano presenti fessurazioni visibili dall'esterno. L'esperienza insegna che è preferibile, nella scelta dell'asse di percussione, assecondare questi piani naturali piuttosto che opporvisi colpendo perpendicolarmente ad essi.

2.1.2 Progetto applicato al ciottolo

Selezionato il ciottolo, si procede alla realizzazione del relativo progetto, adottando una strategia che consta di tre momenti principali:

1) Scelta dell'asse di percussione:

Il criterio con cui si decide di appoggiare il ciottolo sull'incudine dipende soprattutto dalla sua forma, che è connessa con l'esito desiderato. Per definire la forma dei ciottoli viene utilizzato il diagramma di Zingg (Zingg 1935) che permette di classificare la forma dei ciottoli.

2-3) Scelta dell'incudine e del percussore:

Entrambi questi elementi devono rispondere a una duplice necessità: comodità e versatilità d'uso. Nel caso dell'incudine, superfici piane che consentono stabilità, e zone convesse, per localizzare in modo più preciso il punto del contraccolpo. Per quanto riguarda il percussore, dimensioni adeguate alla mano di chi scheggia e forma regolare, per non creare disagi durante la percussione. Inoltre, diverse forme possono rispondere a differenti esigenze di scheggiatura: una superficie ampia e relativamente piana per una percussione non molto mirata, e al contrario una superficie ridotta, come quella che si presenta in una forma più allungata, per un colpo di maggiore precisione.

Si riportano ora 3 esempi relativi agli assi di percussione:

- Percussione secondo l'asse della lunghezza.

L'idea di ottenere un distacco laminare orienta la scelta verso una forma allungata, che non vanifichi le aspettative. Una delle estremità è leggermente più ampia dell'altra e viene scelta come piano di percussione perché si ipotizza che l'apertura possa essere meglio controllata dal punto dell'impatto al piano di appoggio che tende al puntiforme (Fig. 3).

- Percussione trasversale secondo l'asse della larghezza

La dimensione del ciottolo permette di ottenere numerosi elementi utilizzabili.

Come piano di appoggio viene scelto un punto più sporgente sulla superficie del ciottolo affinché il contraccolpo si localizzi nella zona desiderata (Fig. 4)

- Percussione secondo l'asse dello spessore

La scelta dell'asse di percussione privilegia quello dello spessore, affinché il ciottolo sia più stabile sull'incudine, e il piano di appoggio è diffuso (Fig. 5).

3. Esiti

Primo caso: asse della lunghezza

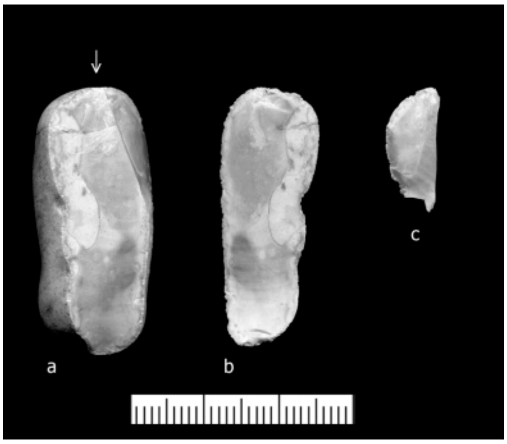

Fig.3 - Ciottolo percosso per l'asse della lunghezza.

Alcuni colpi, dati in sequenza, portano al distacco contemporaneo di due elementi: una "lama oltrepassata" (b), caratterizzata da un bulbo prossimale positivo (vedi glossario), e una piccola scheggia laminare (c) proveniente dalla zona prossimale.

Secondo caso: asse della larghezza

Fig.4 - Ciottolo percosso per l'asse della larghezza

Dopo più colpi in sequenza il ciottolo si apre in due metà, di cui una si frammenta in più parti (b). Nei due elementi principali di b si nota un mezzo bulbo positivo prossimale. Il mezzo ciottolo rimasto intero (a), presenta due bulbi, uno negativo prossimale e uno positivo distale (vedi glossario), dovuti il primo al colpo del percussore, il secondo al contraccolpo dell'incudine.

Terzo caso: asse dello spessore

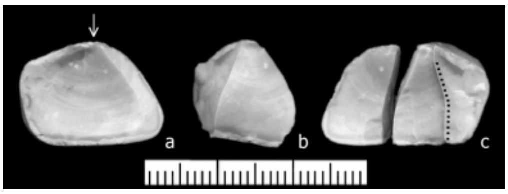

Fig.5 - Ciottolo percosso per l'asse dello spessore.

Dopo più colpi in sequenza il ciottolo si apre in 3 elementi principali: una metà ciottolo con bulbo semplice negativo (a), molto accentuato nella parte prossimale; una scheggia con un bulbo su entrambe le facce (b) (uno positivo semplice e uno diedro); e un'altra metà ciottolo (c), costituente il negativo del diedro frammentatosi in tre parti. Un diedro negativo difficilmente rimane intatto e tende a frantumarsi formando più diedri positivi.

3. Conclusioni

Questo esperimento ha chiarito alcune peculiarità della scheggiatura bipolare, e la sua efficacia.

Un elemento ricorrente è l'importanza della scelta personale nella selezione della forma del materiale da scheggiare: abbiamo notato che ogni singolo scheggiatore mostra una specifica preferenza per un particolare asse di percussione, sia che abbia in mente un'idea precisa dello strumento da ottenere, sia che non esista un progetto predefinito (vedi § 2.1.1).

Un aspetto determinante per l'apertura del ciottolo è il punto di appoggio, ovvero la superficie a contatto con l'incudine da cui proviene il contraccolpo: può essere puntiforme (marcatamente convesso) oppure diffuso (quando la superficie tende ad avere una forma piatta).

Le tracce di quest'ultimo non sono sempre osservabili; in casi sporadici è possibile notare bulbi poco prominenti o, in mancanza di questi scaglie bulbari distali (vedi glossario).

Il fatto che i distacchi avvengano frequentemente in corrispondenza del punto di percussione e che questo sia caratterizzato da un bulbo, suggerisce che il colpo del percussore è preminente rispetto a quello che proviene dal contraccolpo dell'incudine. Solo in alcune occasioni sono stati ottenuti distacchi che presentano sulla medesima faccia due bulbi, uno prossimale e uno distale.

Un ulteriore elemento riscontrabile è il bulbo provvisto di due o tre onde particolarmente pronunciate, che creano una caratteristica "corona" intorno ad esso. Inoltre durante la percussione si creano talvolta dei piccoli distacchi interni che non sono orientabili, e che si possono considerare come scaglie bulbari particolarmente sviluppate.

Infine notiamo la presenza di bulbi diedri, la cui forma è il risultato di un unico colpo e non il margine tra due distacchi consecutivi della stessa faccia.

Al termine della sperimentazione i seguenti elementi possono essere ritenuti diagnostici della tecnica di scheggiatura bipolare: bulbi contrapposti su una stessa faccia, diedri, sbrecciature sul ciottolo dovute al contatto con l'incudine; bulbi a "corona".

4. GLOSSARIO

CONTRACCOLPO: colpo riflesso che proviene dall'incudine.
ESTREMITA' DISTALE: estremità che comprende il punto di appoggio del ciottolo.
ESTREMITA' PROSSIMALE: estremità che comprende il punto di percussione del ciottolo.
SCAGLIA BULBARE: piccolo distacco parassita che altera l'aspetto del bulbo o del suo negativo (Leroi-Gourhan 1991). La scaglia bulbare è definita prossimale quando si origina all'altezza del tallone.

5. BIBLIOGRAFIA

Zingg, T. 1935. Beitrag zur Schotteranalyse. *Schweiz. Min.u. Pet. Mitt.* XV: 39-140.

Laj Pannocchia, F. 1950. L'industria pontiniana della grotta di S. Agostino (Gaeta). *Rivista di Scienze Preistoriche* 5,1-4: 67-86.

Leroi-Gourhan, A. (a cura di) 1991. *Dizionario di Preistoria*, 1. Torino: Giulio Einaudi editore.

The Roman area natural environment: geomorphological features and lithic resources

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SUMMARY: The landscape of the region surrounding Rome - of which the volcanic complexes of the Monti Sabatini and Alban Hills make part. The landscape of this region is the result of the combined action of volcanism and exogenous agents. The morphological aspect of these volcanic complexes is quite similar in the peripheral areas and rather different in their central parts. Denudational processes are mainly due to channelled running waters that show different drainage patterns. The resulting landforms consist of different shaped valleys often controlled by structural factors. A more detailed description is given for a particularly interesting sector of the Monti Sabatini. Flint resources for lithic tool production on pebble are scarse in the Roman area. They are limited to Pliocene and Quaternary fluvial and marine deposits. In a study of 1995, four gravel "flint provinces" were differentiated for central Latium, each characterized by a specific composition in flint types and percentages. The provenance of the chert material used in the two lower Paleolithic sites of La Polledrara di Cecanibbio and Rebibbia-Casal de'Pazzi could be related to these provinces.

1. GEOMORPHOLOGICAL FEATURES

This paper describes the main morphological features of the region surrounding Rome, which extends as far as the foot of the Latian Subapennines. This region includes a good part of the Campagna Romana (or Agro Romano), a term traditionally used to indicate the area, having no well-defined boundaries, which surrounds the Eternal City (Almagià 1976). It is a generally hilly region with altitudes gradually decreasing from a top level of about 1000 m toward the sea and also characterized by more or less wide coastal plains among which the deltaic plain of the Tiber river stands out.

The present morphological aspect of this region is the result of the combined action of the Middle and Late Quaternary volcanism and of the exogenous agents. The most important landforms encountered are volcanic, due to the activity of the Monti Sabatini and Alban Hills complexes.

The volcanic activity of the Monti Sabatini complex was mainly of areal kind. The volcanic products were ejected from numerous centres widespread over an area of about 1500 km^2; a main central edifice originated only in the eastern sector, where the Sacrofano Volcano developed. The volcanic activity started at the margins of the main graben and then migrated to its centre, following tectonic dislocations of regional importance. It caused the emplacement of a large amount of products (about 180 km^3) prevailingly made up of pyroclastic flows, hydromagmatic products, lava sheets and pyroclastic fall products. As a consequence of its mainly areal activity, the Monti Sabatini complex generally shows a very smooth morphology characterized by low relief and structural surfaces originated by the emplacement of volcanites (Biasini *et al.* 1993).

The Alban Hills volcanic complex is characterized by an important central edifice, which erupted most of the volcanic products. The activity of this volcano had three main phases. The first phase occurred between 0.5 – 0.36 Ma BP; about 34 km^3 of products were erupted and at least four huge pyroclastic flows were emplaced; these products extended regularly around the central edifice and were the last to reach as far as the periphery of the Roman area. This first phase ended with the summit caldera collapse. The second phase was very similar to the previous one; the volcanic activity concentrated again in the central area where a second smaller central edifice grew up inside the collapsed area. During this phase the most important lava flows were erupted (e.g. the Capo di Bove flow on which the famous Appian Way partially winds). The third, final phase was characterized by violent hydromagmatic activity from several eccentric craters, located in the southwestern sector of the volcanic complex; at present the largest of these craters hold the Lake Albano and the Lake of Nemi (Caputo *et al.* 1993).

In spite of the similarity of their eruptive cycle, the Monti Sabatini and Alban Hills volcanic complexes are morphologically different, at least for their central parts.

The Monti Sabatini landscape is marked by the contrast between the composite aspect of the central sector, where most of the positive and negative volcanic forms are present, and the smooth and regular trend of the peripheral sectors. The positive volcanic forms (mainly scoria cones) are responsible for the greatest elevation in the northern part of the central sector where, at Monte Rocca Romana, to the North of Lago di Bracciano, the maximum elevation is reached (612 m a.s.l.). The wide subcircular depression, occupied by the Lago di Bracciano is the most striking negative form of the whole complex. Other important subcircular or ellipsoidal depressions are those of Martignano, Baccano and Sacrofano, all to the East of Bracciano. The origin and evolution of these four depressions followed different paths. The former had an essentially volcano-tectonic origin, while the others have the typical features of volcanic centres with predominantly explosive activity.

On the contrary, the existence of the central edifice makes the Alban Hills landscape much sharper, at least in the central area where the emission centres are concentrated. In fact this volcanic complex has the shape of a large edifice with rather gentle slopes, slightly convex and cut by many small valleys. The summit area is characterized by two walls with very steep slopes; the outer wall is the remnant of the Tuscolano-Artemisio edifice and it has a horseshoe shape, being open to the West; the inner wall is the remnant of the Faete edifice and it rises from the flat plain that occurs inside the outer wall.

The morphological features of the peripheral sectors of the Alban Hills and of the Monti Sabatini are quite similar. The repeated pyroclastic and lava flows caused the formation of surfaces slightly inclined from the eruptive centres outward; on these surfaces the erosive action of the exogenous agents has produced its modelling effects.

The drainage networks of the Alban Hills area is affected by channelled running waters that form drainage networks, which change in density and pattern (centrifugal, centripetal, annular and parallel) according to different factors. The watercourses flowing on northern and northwestern slopes join the Aniene river; drainage networks have a centrifugal radial pattern at the headwaters, then they assume an overall parallel pattern, mainly NW-SE oriented. Streams draining the western slopes join the Tiber river downvalley of its junction with the Aniene river. On these slopes streams mainly flow in a SE-NW direction and the drainage network geometry becomes similar to a subparallel pattern. The southwestern slopes include also numerous small catchments, which drain directly into the sea, from the mouth of the Tiber river to Anzio.

Denudational processes, which affect the Alban Hills area, are mainly due to surface running water. Landforms resulting from the action of channelled waters are definitely the most important; they consist of differently shaped valleys, often controlled by structural factors and partly by microclimatic conditions that change with altitude. The trough-floored valleys – generally of small extent - are the most widespread landforms along the slopes of the inner volcanic edifice and along the upper slopes of the outer edifice. The V-shaped valleys locally represent a landform change being the continuation, interruption, or beginning of trough- and flat-floored valleys. In general they are not frequent and at present they often show deepening riverbed erosion. The flat-floored valleys, frequently being covered by alluvial deposits on their bottom, are very widespread in the western and southwestern sectors, as well as in the northern one near the Monti Prenestini.

The drainage network of the Monti Sabatini volcanic complex seems to be influenced only by the wide and low relief surfaces originated by volcanite emplacement and by the large depressions of Bracciano, Baccano and Sacrofano. The drainage network varies in density from zone to zone and tends to show a centrifugal pattern on the whole. In this general drainage pattern, several configurations can be easily isolated and broadly classified into different types: centripetal, centrifugal, annular, parallel and dendritic. The morphological evolution and the present arrangement of the Monti Sabatini volcanic complex are the result of both the cited volcanic events and the exogenous processes. The most evident exogenous processes are due to channelled running waters that dissected the volcanic plateau into large shelves, which are separated by deep valleys drawing a drainage network with different characteristics from zone to zone. However a great role had also the strong control by recent tectonics, as various morphotectonic studies show (Biasini *et al.* 1993; Ciccacci *et al*. 1988, 1989).

The Sacrofano-Baccano volcano is described in detail; it represents the only central edifice of the whole Monti Sabatini complex and its evolution may have been similar to that of the Alban Hills. The Sacrofano-Baccano area, located in the eastern sector, had a morphological evolution markedly affected by both volcanic and tectonic events, which involved the same valley of the Tiber river. Such evolution took place through four main phases (Fig. 1).

In the first phase the products of the volcanic centre of Sacrofano built up the central volcanic edifice, while many scoria cones originated in the peripheral zones of the main volcano. On the newly created relief a radial centrifugal drainage developed, which cut deep valleys mainly developed on the northern slope of the volcano (Fig. 1.1). The emplacement of the Sacrofano lower pyroclastic flow, in particular, was strongly controlled by the preexisting topography and was responsible for the morphological changes also in the most marginal areas.

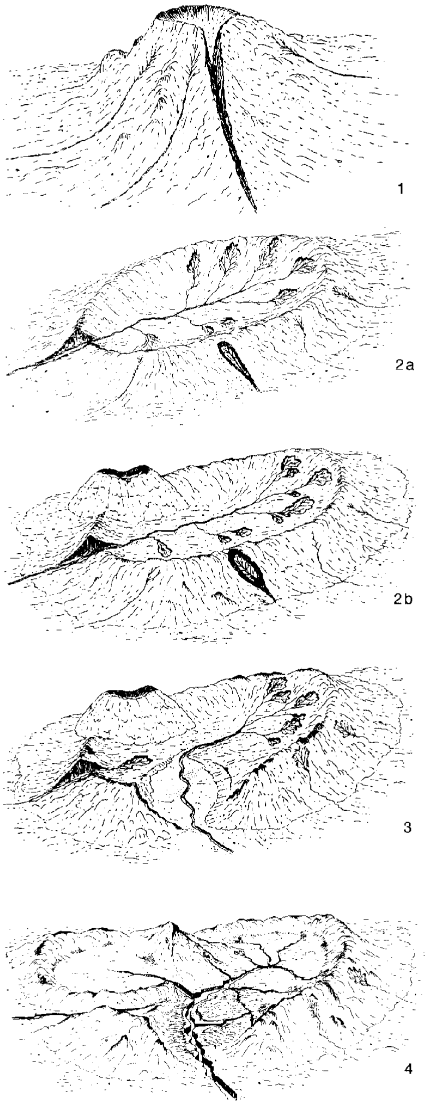

Fig.1 - Geomorphological evolution of the Sacrofano and Baccano depressions (Ciccacci *et al.* 1988, modified).

To the North of the Sacrofano volcano, in fact, this flow was channelled in the ancient valley of the Tiber river which was dammed and forced to flow in the present and more eastern position (Alvarez 1973). At the end of this first phase, the volcano summit collapsed and consequently a large elliptical caldera formed, with its major axis NE-SW oriented, a tectonic direction of regional importance; in fact it clearly controlled the morphological evolution of the eastern sector of the Monti Sabatini volcanic complex as well as its volcanic history.

The presence of the Sacrofano caldera dominates the second phase (Fig. 1.2a). The collapse of the volcano summit cut off the radial valley headwaters, while the valleys themselves were partially filled with the pyroclastic flow. Within the caldera a new centripetal drainage network was emplaced which joined the main trunk flowing from NE to SW, following the caldera major axis and breaking the depression edge southwestward. At the end of this phase a hydromagmatic activity developed at an uncertain centre. The products of this activity crop out on the northern and eastern rim of the caldera; the same kind of activity is responsible for the building up of a tuff-cone (Monte Razzano) on the western edge of the Sacrofano caldera (Fig. 1.2b).

The third phase is marked by consistent modifications of surface drainage. The main trunk of the intracalderic drainage network, NE-SW oriented, is forced to flow southward inside the valley in connection with the crater since the first evolutive phase. This deviation was probably due to the headward erosion of a river channel (Rio Cremera), which breached the southern rim of the caldera depression and captured the intracalderic drainage network (Fig. 1.3). This piracy was probably made easier by a volcanic event, which would have interrupted the southern edge of the Sacrofano caldera.

The fourth phase of the evolution of this area started with the beginning of the Baccano eruptive centre activity. The volcanic events of this phase deeply changed the previous landscape. The western edge of the Sacrofano caldera was firstly buried by the Baccano lower hydromagmatic unit and finally interrupted by the main collapse of the Baccano caldera (Fig. 1.4), which was accompanied by the faulting of the Monte Razzano tuff cone. The Baccano products caused the progressive filling up of the Sacrofano depression; as consequence, subhorizontal structural surfaces originated that raised the caldera bottom and caused the drainage network rejuvenation.

2. LITHIC RESOURCES

In the following text, attention is concentrated on the siliceous resources for lower paleolithic tool production, although other provenance studies for this period have been done in the Campagna Romana, e.g. on the origin of the leucitite blocks encountered at the La Polledrara site (Anzidei *et al.* 1995).

The Roman area is characterized by both volcanic and continental depositional environments (Conato *et al.* 1980; De Rita *et al.* 1988; Di Filippo 1993; Marra & Rosa 1995). Generally, the area is poor in siliceous resources for tool production: the volcanic deposits do not contain chert at all, whereas the continental formations contain chert veins only locally. In this area, pebbles made up of chert and siliceous limestone are essentially limited to Pliocene and Quaternary fluvial and marine deposits. And therein, unweathered flint pebbles are not abundant.

In 1995 a research was carried out for the Soprintendenza Archeologica di Roma to establish the provenance of the pebbles used for the production of the lithic tools encountered at the lower-Paleolithic sites of “Casal de’ Pazzi” and “La Polledrara di Cecanibbio” (for the geological and paleoenvironmental aspects of these sites, see Anzidei *et al.* 1984, 1988, 1989; Anzidei & Arnoldus-Huyzendveld 1992; Arnoldus-Huyzendveld & Anzidei 1993).

At the La Polledrara site, the flint is mainly of one type: medium grained, dark grey, unweathered and with a black or grey, thick cortex. The lithic industry encountered at the Casal de' Pazzi site is basically derived from two types of material: predominantly unweathered, fine and medium textured flint with light colors (yellowish, greyish, rarely brown or reddish), and, more rarely, a second type: a greyish flint with many inclusions. Up to now only two tools were found to be derived from flint similar to that of La Polledrara (dark-grey). The first type of the Casal de' Pazzi site seems at first sight identical to what was used in the roman and pontinian area during the middle Palaeolithic.

The procedure for the provenance study has been first to identify on the geological maps the sediments containing siliceous veins and pebbles in a large part of the coastal area of central Latium. Successively, the lithological composition of various Pliocene and Pleistocene pebble formations has been verified in the field. The choice to limit the field research to gravelly deposits is justified by the exclusive use of tools on pebbles during the Lower Paleolithic. Samples were collected at ten geological sites, considered to represent sufficiently the variability of central Latium. On all the sites, at least of 100 pebbles larger than 3 cm, the lithological composition, the degree of weathering and the color were determined in the field. The results of the counting are given in table 1.

The differences in flint percentage and composition between the various sample turned out to be remarkable. On the basis of the data collected, four "flint provinces" for the central area of Latium were proposed, intended to serve as a tool for further research in this field (Fig. 2, from Anzidei *et al.* 1995):

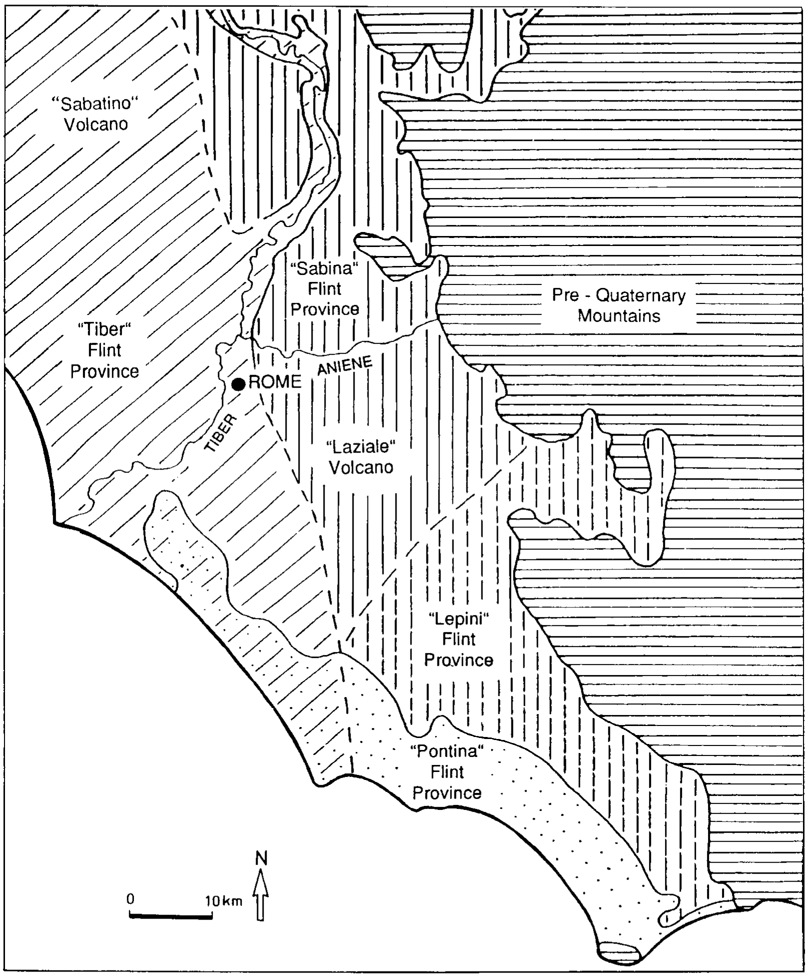

Fig.2 - Proposal for the "flint provinces" of the area around Rome: "Tiber" province, "Sabina" province, "Pontina" province, "Lepini" province.

T: "Tiber" province (fluvial-deltaic and coastal facies)
S: "Sabina" province (fluvial-deltaic facies)
P: "Pontina" province (coastal facies)
L: "Lepini" province (fluvial facies).

The Tiber and Pontina flint province overlap partially in space. This must be due to the activity of the Latium volcano (Alban Hills) in the Midde Pleistocene, which forced the limit of the Tiber province to the northwest.

As far as the flint type of the La Polledrara site, the geological study showed that they must have been derived from a formation belonging to the Tiber province. In fact, flint pebbles of similar size, colour and texture, occur in a part of the "Ponte Galeria Formation" (belonging to the lower Middle Pleistocene "Sicilian", age 0,8-0,6 Ma; Conato *et al.* 1980), presently exposed about 3 km to the south of La Polledrara, about 40 m below the site level, along the Galeria and Magliana valleys. Also other formations containing the same dark-grey flint occur in the area, i. e.: part of the S. Cosimato and Aurelia formations, correlated respectively to isotopic stages 11 (0,48-0.37 Ma) and 9 (0.37-0.27 Ma; De Rita *et al.* 1991). However, considering the limited extension of the S. Cosimato formation, only the pebbly part of the Aurelia formation, representing a contemporaneous river bed downstream from the site, seems to be a reasonable alternative hypothetical source for the dark-grey flint.

Since all three formations identified contain pebbly layers only downstream from the site, the presence of the flint pebbles at the La Polledrara site must be assigned in any case to human transport.

The two flint types of Casal de' Pazzi do not derive from any of the Tiber flint province. In the scheme proposed, the source of the dominant type of flint found at Casal de' Pazzi (type I, light colored, unweathered) must have been the pebbly formations of the Pontina flint province. Instead, the source of the subordinate type (type II, grey with inclusions) must have been the pebbly formations of the Sabina flint province, probably the local river bed of the paleo-Aniene.

Up to now, no provenance studies for the lithic material have been done for the other lower paleolithic sites of the Roman area. The present identification of the flint provinces could direct this research.

Tab.1 - Flint types of the samples collected around Rome.

FLINT PRO-VINCE	Nr. sam-ple	Code sample	Geological formation of sample	total % flint	% dark grey unweath-ered flint	% light coloured unweath-ered flint	% red unweath-ered flint	% grey weath-ered flint	% light coloured or red weathered flint
Tiber	1	GAL	Ponte Galeria formation (middle Pleistocene)	11	3 *	0		8	0
	2	COS	San Cosimato formation (middle Pleistocene)	36	6 *	1		19	10
	3	AUR	Aurelia formation (middle Pleist.)	30	2 *	1		17	10
	4	CAL	Tor Caldara –Anzio ("qsm", middle Pleistocene)	37	32 *	5		0	0
Sabina	5	ACQ	Acquaviva (“Q2p”, Plio-Pleistocene)	2	2 ***	0		0	0
	6	ARC	Casino d'Arce (“Q2-1”, Plio-Pleistocene)	0	0	0		0	0
Pontina	7	LAT	Latina quarry (Pleistocene)	56	1	45 **	8	1	
	8	CIR	Parco Circeo – Sabaudia (Pleist.)	72	4	55 **	10	3	
	9	IEM	Campo Iemini –Torvaianica (Pleistocene)	73	2	56 **	0	15	
Lepini	10	NOR	Norma – Mt. Lepini (Pleistocene - Holocene)	0	0	0		0	0

* La Polledrara flint type
** Casal De' Pazzi flint type I
*** Casal De' Pazzi flint type II.

4. REFERENCES

Almagià, R. 1976. *Le Regioni d'Italia. XI: Lazio*. Torino: U.T.E.T.

Alvarez, W. 1973. Ancient course of Tevere river near Rome: an introduction to the Middle Pleistocene volcanic stratigraphy of Central Italy. *Geol. Soc. Am. Bull.* 84: 749-758.

Anzidei, A.P. & Arnoldus-Huyzendveld, A. 1992. The middle Pleistocene site of La Polledrara di Cecanibbio (Rome, Italy). *Fourth Conference of Italian Archaeology, B.A.R., I.S.*: 141-153.

Anzidei, A.P., Angelelli, F., Arnoldus-Huyzendveld, A., Caloi, L., Palombo, M.P. & Segre, A.G. 1989. Le gisement Pleistocène de la Polledrara di Cecanibbio (Rome, Italie). *L'Anthropologie* XCIII, 3: 749-781.

Anzidei, A.P., Angelelli, F., Caloi, L., Damiani, I., Pacciarelli, M., Palombo, M.R. & Segre, A.G. 1988. Il giacimento pleistocenico de "La Polledrara" di Cecanibbio (Roma) - Relazione preliminare. *Archeologia Laziale* 9: 361-368.

Anzidei, A.P., Arnoldus-Huyzendveld, A., Lemorini, L., Caloi, L. & Palombo, M.R. 1999. Two Middle Pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia - Casal de' Pazzi. In *The role of early humans in the accumulation of European Lower and Middle Palaeolithic bone assemblages*. Monographien des Römisch-Germanischen Zentralmuseums 42. Mainz: 173-195.

Anzidei, A.P., Cassoli, P.F., Ruffo, M. & Segre, A.G. 1984.Risultati preliminari dello scavo di un deposito pleistocenico in località Rebibbia-Casal de' Pazzi. *Atti del XXIV Convegno dell'Istituto Italiano di Preistoria e Protostoria.*

Arnoldus-Huyzendveld, A & Anzidei, A.P. 1993. Ricostruzione di un ambiente fluvio-lacustre nella regione vulcanica di Roma (la Polledrara di Cecanibbio). *Atti XXX Riunione Scientifica Istituto Italiano di Preistoria e Protostoria, Firenze*: 151-165.

Biasini, A., Buonasorte, G., Ciccacci, S., Fredi, P. & Lupia Palmieri, E. 1993. Geomorphological characteristics. In: Sabatini Volcanic Complex. *Quad. Ric. Scien. C.N.R* 11: 80-94.

Caputo, C., Ciccacci, S., De Rita, D., Fredi, P., Lupia Palmieri, E. & Salvini, F. 1993. Drainage Pattern and Tectonics in some volcanic Areas of Latium (Italy). *Geologica Romana* 29: 1-13.

Ciccacci, S., De Rita, D. & Fredi, P. 1988. Studio geomorfologico delle depressioni vulcaniche di Sacrofano e Baccano nei Monti Sabatini (Lazio). *Mem. Soc. Geol. It.* 35: 833-845.

Ciccacci, S., De Rita, D. & Fredi, P. 1989. Geomorfologia quantitativa e morfotettonica dell'area di Morlupo-Castelnuovo di Porto nei Monti Sabatini (Lazio). *Geogr. Fis. Dinam. Quat. Suppl.* 1: 197-206.

Conato, V., Esu, D., Malatesta, A. & Zarlenga, F. 1980. New data on the Pleistocene of Rome. *Quaternaria* 21: 131-176.

De Rita, D., Funiciello, R. & Parotto, M., 1988. *Carta geologica del Complesso Vulcanico dei Colli Albani (Vulcano Laziale). Scale 1:50.000. C.N.R., P.F.G.* Roma: Gruppo Nazionale per la Vulcanologia.

De Rita, D., Rosa, C. & Zarlenga, F. 1991. Un'ipotesi di correlazione tra la sedimentazione lungo la costa tirrenica della Campagna Romana e l'attività vulcanica dei Colli Albani (Pleistocene medio-superiore). Prog. Strategico Crosta Profonda, Sottoprogetto CROP 11. *Studi Geol. Camerti. Vol. Spec.* 1991/2: 343-350.

Di Filippo, M. (ed.) 1993. *Sabatini Volcanic Complex; scale 1:50.000.* Roma: C.N.R.

Marra, F. & Rosa, C., 1995. Stratigrafia e assetto geologico dell'area romana, In Funiciello, R. (ed.), *La geologia di Roma. Il centro storico*: 49-118. Roma: Istituto Nazionale di Geofisica, Dipartimento di Scienze Geologiche, Servizio Geologico Nazionale.

The World of Elephants - International Congress, Rome 2001

A Middle Pleistocene deposit with *Elephas antiquus* remains near Colleferro (Roma)

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SUMMARY: A new Middle Pleistocene deposit with remains of *Elephas antiquus, Bos primigenius, Cervus elaphus* and lower Palaeolithic implements has been discovered in South-Western "Campagna Romana" (Colleferro, Rome). While the stratigraphic position suggests an attribution to the lower Middle Pleistocene, the characters of the fauna do not allow a full correlation with Fontana Ranuccio FU.

1. INTRODUCTION

The fossil deposit is located in locality Colle Pantanaccio, in downtown Colleferro, (Fig. 1). The first notice to the Archaeological Group of Colleferro was given in 1994 by a student, when fossil bones fragments were spotted in a section cut during works of house building. A digging test carried out in December 1999 allowed to locate an elephant tusk in a clay level (Upper Unit) and vertebrate remains and scanty lithic industry in the levels below (Lower Unit).

The systematic diggings, currently in progress in the Lower Unit, were resumed in October 2000 to better understand the geologic setting of the site and to make an estimate of the actual concentration of archaeological and palaeontological evidence, foreseeing the building of a Museum.

2. GEOLOGICAL BACKGROUND

The Latina Valley is a tectonic depression with a carbonatic substratum, starting from 700-110 m below ground level (Cassa per il Mezzogiorno 1972), overlain by synorogenetic terrigenous deposits, fluvial and lacustrine sediments and volcanics mainly from the Colli Albani volcanic district (Alberti *et al.* 1975; Parotto & Praturlon 1975; De Rita *et al.* 1987). In the pre-volcanic topography, the site was located in a valley of the Paleo-Sacco river, with water-drainage towards NW, opposite to the present one. During the Middle Pleistocene the area had a reversal of water-drainage due to the emplacements of Colli Albani volcanics (II pyroclastic flow of the Tuscolano Artemisio phase, sensu De Rita *et al.* 1988). During this time of transition, the duration of which is still undetermined, the whole area was probably swamped.

The first observations on the stratigraphy of Colle Pantanaccio, carried out on a composed artificial section, enable us to the identification of:

- a Lower Unit (observed thickness approx. 3 m) made of materials of volcanic origin that were sedimented or resedimented in a swampy-lacustrine environment, with evidence of initial processes of pedogenesis; many fragmentary fossil remains were found in this unit;
- an Upper Unit (observed thickness approx.

Fig.1 - Location of Colle Pantanaccio, near Colleferro.

2.5 m, Fig. 2), made of clays in the lower part, and of sands in the upper. The sediments and the structures suggest an anoxic environment characterized by shallow waters with low hydrodynamism; from this argillaceous facies an evolution towards a fluvial environment was observed, but always characterized by relatively shallow waters, at times emerged, corresponding to the medium-fine sands.

The sediments include macrobotanical remains. Palaeobotanic analyses currently in progress will give additional information allowing for palaeoenvironmental reconstruction.

3. FAUNA

Many remains have been recovered in the Lower Unit. The bones show traces of transport and various degrees of alteration. The following taxa have been recognized:

Elephas antiquus: one tusk (Fig. 3) displaying the typical taxonomic characters of the species, such as the low curving and the inner structure with a pattern of Schreger lines having angles greather than 110° in the external portion (Palombo & Villa 2001); in addition, the pelvis of a young individual, with an incompletely ossified pubic symphisis.

Bos primigenius: a portion of skull, with a horn and a premolar; morphology and dimensions fall within the field of variability of Middle Pleistocene taxa (Caloi & Palombo 1980).

Cervidae gen. spec. indet.: some fragmentary remains of little diagnostic meaning, such as vertebrae and portions of long bones, have also been discovered.

From the Upper Unit a tusk approximately 4 meters long (Fig. 4) was recovered. The tusk, lying on a clay layer, was in a good state of

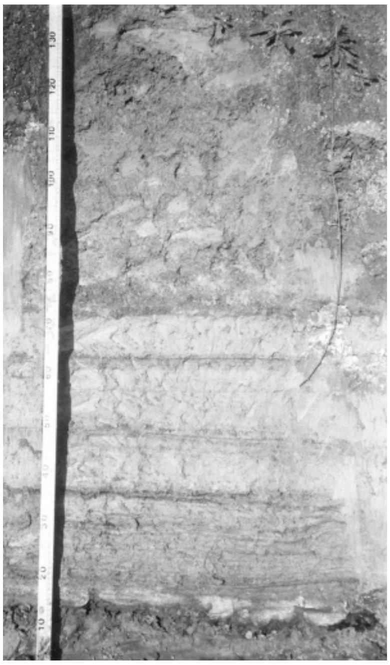

Fig.2 - Section of the Upper Unit of Colle Pantanaccio.

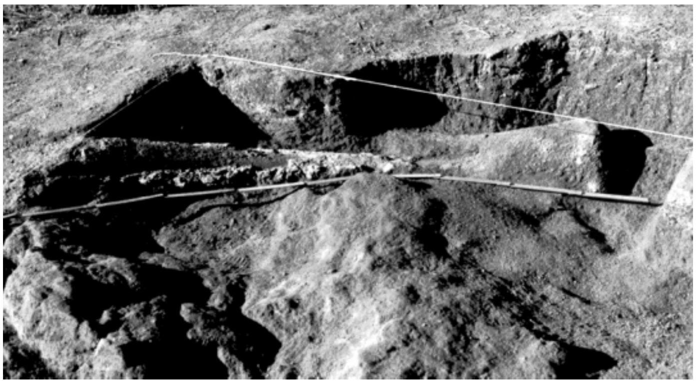

Fig.3 - Tusk of *Elephas antiquus* from the Lower Unit.

preservation and displayed typical features of the species *Elephas antiquus* (Maccagno 1962). A scapula and a fragment of lower jaw of a cervid (*?Cervus elaphus*) were found in the same unit .

4. LITHIC INDUSTRY

Scanty stone implements, made knapping small silicious pebbles, were also retrieved.

From the Lower Unit:

- a scraper on a core;
- a borer adjacent to a clactonian notch;
- a carinated borer ;
- a core with a single striking platform.

From the Upper Unit:

- one flake.

Fig.4 - Tusk of *Elephas antiquus* from the Upper Unit.

5. FINAL REMARKS

This deposit confirms the frequency of site with *Elephas antiquus* in the Middle Pleistocene of the “Campagna Romana” (Palombo 1986, 1995). Faunas with elephants are relatively common in the Plio-Pleistocene of the area, as the well known deposits near Colle Pantanaccio which include Costa San Giacomo (Costa San Giacomo FU) from which remains of *Anancus arvernesis* in probable association with *Mammuthus meridionalis* have been found; and the one of Fontana Ranuccio (Fontana Ranuccio FU) in which many remains of *Elephas antiquus* (Biddittu *et al.* 1979) have also been discovered. Among the nearby localities, on which only preliminary information is available, the most important seems Quartaccio near Paliano (Frosinone) (unpublished data). The remains from Quartaccio were recovered during surveys and surface collections in a deposit with the same sedimentary characteristics as Colle Pantanaccio. After a first examination of fragmented remains, *Elephas antiquus*, *Equus* sp. and *Bos primigenius* were all identified.

The data currently available do not allow a reliable estimate of the evolutionary degree of the faunas from Colle Pantanaccio; however the nature of the deposits, the presence of iron crusts and of many well preserved crystals of leucite suggest a preliminary correlation with the nearby deposit of Fontana Ranuccio, dated at 458 ka by K-Ar (Biddittu *et al.* 1979). Further digging, analysis and research will allow to better define the position of Colle Pantanaccio within the Middle Pleistocene faunas of Central Italy.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Alberti, A.U., Bergomi, C., Catenacci, V., Centamore, V., Cestari, G., Chiocchini, M., Chiocchini, U., Manganelli, V., Molinari-Paganelli, V., Panseri-Crescenzi, C., Salvati L. & Tilia-Zuccari, A. 1975. *Note illustrative della Carta Geologica d'Italia 1: 50.000, F° 389 Anagni*. Roma: Servizio Geologico d’Italia.

Biddittu, I., Cassoli, P., Radicati, F., di Brozzolo F., Segre, A.G., Nardini, E. & Villa, I. 1979. Anagni, K-Ar dated lower and middle Pleistocene site, Central Italy: preliminary report. *Quaternaria*, 21: 53-71.

Caloi, L., Palombo, M.R. 1980 Resti di mammiferi del Pleistocene medio di Malagrotta (Roma). *Boll. Serv. Geol. Ital.*, 100 (1979): 141-188.

Cassa per il Mezzogiorno. 1972. *Prospezione geoelettrica nella Valle Latina*.

De Rita, D., Funiciello, R. & Rosa, C. 1987. L'influenza dell'attività del Complesso vulcanico dei Colli Albani sullo sviluppo idrografico della Campagna Romana: l'alta Valle del Sacco. *Rend. Soc. Geol. It.*, 12: 47-50.

De Rita, D., Funiciello, R. & Parotto, M. 1988. *Carta geologica del Complesso vulcanico dei Colli Albani*. C.N.R., Progetto Finalizzato Geodinamica, G.N.V. Firenze: S.E.L.C.A.

Maccagno, A.M. 1962. Gli elefanti fossili di Riano (Roma). *Geologica Romana*, 1: 33-132.

Palombo, M.R. 1986. Observations sur Elephas antiquus Falconer e Cautley du Pléistocène moyen d'Italie: essai d' évaluation des caractères dentaires. *Geologica Romana*, 23 (1984): 99-110. Roma.

Palombo, M.R. 1995. Gli elefanti del Pliocene superiore e del Pleistocene dell'Italia centrale peninsulare; alcune considerazioni. *Studi Geologici Camerti, vol. spec. B 1994*: 447-457.

Palombo, M.R. & Villa, P. 2001. Schreger lines as support in the Elephantinae identification. *this volume.*

Parotto, M. & Praturlon, A. 1975. Geological summary of the central Apennines. *Quaderni della Ricerca Scientifica*, 90: 257-300.

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Middle Pleistocene geology of the "Bassa Campagna Romana"

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SUMMARY: This paper describes the main geological characters of the "Bassa Campagna Romana" during the Middle Pleistocene. In this period the "Bassa Campagna Romana", comprised between the city of Rome and the Tyrrhenian sea, has been interested by complex geological processes including extensional tectonism related to the development of the Tyrrhenian basin back arc, volcanism, and the glacio-eustatic variations of the sea level related to global climatic changes. The Tiber river is one of the most important geological element present in the area; most of the deposits outcropping in the area are, in fact, alluvial sediments of the Tiber and its tributaries, often interbedded with volcanic deposits from the Colli Albani and the Sabatini volcanic districts. The successions, which sometimes contain Palaeolithic industry, has been subdivided, by the presence of unconformities, in several orders or cycles of alluvial fills interbedded with volcanic deposits.

1. STRATIGRAPHY OF THE AREA*

During the Middle Pleistocene to the recent, Central Italy has been interested by complex geological processes including:

- general uplifting of the area due to hysosthatic re-equilibration, after the Apennine orogeny, and to extensional tectonism of the Tyrrhenian margin related to the development of the Tyrrhenian back arc basin;
- extensive alkali-potassic volcanism from mainly explosive volcanoes forming a NW-trending elongated belt, parallel to the Tyrrhenian sea coast;
- glacio-eustatic variations of the sea level.

The interplay among these processes are responsible for the morphological setting of Central Italy and, in particular, of the "Bassa Campagna Romana". The geometry and the facies characteristics of the volcanoclastic succession of the Tiber valley indicate that its morphology was modified many times during the Middle Pleistocene, both for the effects of local tectonics, the emplacement of large-volume ignimbrites and oscillations of the sea level.

In this paper we present a synthesis of the geological studies that have been made in the last ten years on this area, with emphasis to a new interpretation that has been possible by the data collected during the recent field survey for the new 1:50.000 geological map of Italy.

Most of the Middle Pleistocene deposits outcropping in the "Bassa Campagna Romana" are alluvial sediments of the Tiber river and of its tributaries, which represent several orders or

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* The new data reported in this section were obtained during the survey of the "Roma" and the "Albano" geological maps (originally at the 1:10000 scale) of which the field operators have been Alessandra Esposito and Marina Fabbri. Guido Giordano has been the field research Director and Renato Funiciello and Donatella de Rita have been the Chief Supervisors. Francesco Zarlenga has been the Responsible for the survey of sedimentary Quaternary units.

cycles of alluvial fills. In some cases and at the top of the sequence, they show brackish and marine facies as at the Torre del Pagliaccetto, San Cosimato and Vitinia sections (Conato *et al.* 1980). This succession of sediments, interbedded with volcanic deposits from the Colli Albani (also known as Alban Hills), almost 20 km south-east of Roma, and the Sabatini volcanic Districts, more than 30 km north of Roma, lie unconformably on Lower Middle Pleistocene (P. Galeria Formation) and older pre-volcanic sediments.

The Sabatini volcanic district is a large volcanic area with many craters and calderas located around a central collapsed area at the present infilled by the Bracciano lake. Volcanic activity started around 600 ka ago from craters located in the eastern sector. Here, the Sacrofano volcano, the most active of the sector, had mainly explosive activity erupting fall scoriae and pumices and huge pyroclastic flows. The fall levels and some of the pyroclastic flow units reached the Bassa Campagna Romana: the "Tufo giallo della Via Tiberina" (549 ka), the "Prima Porta" unit (514 ka) and the "Tufo giallo di Sacrofano" (333 ka). Volcanism was contemporaneously active in the central sector of the volcanic district where fracture systems erupting lava flows and explosive craters developed around the central volcano-tectonic depression of the Bracciano lake. From the Vigna di Valle crater, south of the Bracciano lake, was erupted the "Tufo rosso a scorie nere" ignimbrite (430 ka).

The Colli Albani volcanic district is a central volcano whose activity can be subdivided in three main Epoch (*sensu* Fisher & Schmincke 1984). During the first Epoch, from 600 ka to 300 ka, the central Tuscolano-Artemisio volcano was active, which erupted several pyroclastic flow units, largely reaching the Bassa Campagna Romana. After the collapse of the edifice and the setting of the Tuscolano-Artemisio caldera, volcanic activity was located within the smaller Le Faete central edifice, grew inside the collapsed area. Final hydromagmatic explosions from eccentric craters ended the volcanism less than 30 ka ago.

The base of the volcanoclastic succession of the "Bassa Campagna Romana" is the Ponte Galeria Formation. It is made of interbedded conglomerates, sands and clays interpreted as the deposits of the ancient Tiber river and its delta in the medium-higher part, named Paleotiber.

The geometry, the facies characteristics and the thickness of the Ponte Galeria formation indicate that, before the beginning of the alkali potassic volcanism, about 600 ka ago, the Paleotiber was in an easternmost position with respect to the present and its delta was in the area of Ponte Galeria. Ponte Galeria formation has been studied by many Authors and several interpretations of its sequence have been proposed (Conato *et al.* 1980; Malatesta & Zarlenga 1986; Milli 1992, 1997; Marra & Rosa 1995; Marra *et al.* 1994).

On top of this sequence, the "Tor de Cenci" unit is present. The "Tor de Cenci" unit is the deposit of pyroclastic flows erupted from the central Tuscolano-Artemisio volcano in the Colli Albani volcanic district.

The "Tor de Cenci" unit has been dated by Karner *et al.* (1994) 561 ka. It is one of the four ignimbrites, separated by paleosoils, recognized during the recent field research as belonging to the deposits generally known as "Tufi pisolitici".

Almost contemporaneously to the "Tor de Cenci" unit, interbedded with synvolcanic sediments, is another ignimbrite unit erupted by the Sacrofano volcano in the Sabatini volcanic District. This ignimbrite, named the "Tufo giallo della Via Tiberina" was erupted 549 ka ago.

These eruptions had a strong impact on the sedimentary environment of the Roman area. Many minor river valleys were completly infilled and the Tiber, North of Rome, had its course moved westward. Enormous volumes of sediments were rapidly transported by mass flow and high sediments-concentration flow processes. Thick volcanoclastic deposits, both interbedded and on top of the ignimbrites are the products of this sineruption phase.

The volcanic and volcanoclastic sediments are cut by an important erosion surface that we consider as due to the oscillation of the sea level related to the OIS 14.

On this surface, fluvial sediments interbedded with several volcanic units are present.

The fluvial sediments are conglomerates, sands and clays rich in volcanic component and locally interested by travertine deposits. The volcanoclastic deposits are also known as "Valle Giulia" unit as defined in the Roman urban area (Marra & Rosa 1994).

The volcanic units come from both the Sabatini and the Colli Albani volcanic Districts. They are the "Palatino unit" dated 533 ka and the "Casale del Cavaliere unit" from the Tuscolano-Artemisio volcano, the "Prima Porta" unit, dated 514 ka years and fall deposits from the Sacrofano volcano in the Sabatini volcanic district.

This complex sedimentary cycle is closed by a strong uplift of 20-30 m, started during the first volcanic eruptions and by a contemporaneous low stand of the sea level, due to the glacio eustatism, which produced an erosion surface, that we relate to the isotope stage 12, which cut all older sediments.

After this phase a new chapter in the geology of Bassa Campagna Romana begins, in fact erosion and sedimentation in the palaeovalleys have been strongly affected by the eustatic cycles, during the low standing of the sea level large regional erosion surfaces and during high stand of the sea level the sedimentation in the palaeovalley were produced; these sedimentary cycles represent "fourth order depositional sequences" (De Rita *et al.* 1993).

This first surface is filled by complex volcanics or by sediments. The volcanic unit are lava flows, "Pozzolane rosse" and "Pozzolane nere" units from the Colli Albani volcano that are interbedded with syneruption pebble-sandy fluvial sediments.

The sediments related to the oxygen isotope stage 11 are characterised by the absence of black scoriae coming from the "Tufo rosso a scorie nere". They constitute the S. Cosimato Formation (Conato *et al.* 1980; Malatesta & Zarlenga 1986) and, from a palaeontological point of view, they could be correlated to the Fontana Ranuccio Faunistic Units (FU) (Caloi & Palombo 1995).

Probably at the end of this cycle, or during the higher part the "Tufo rosso a scorie nere" ignimbrite, dated 430 ka, from the Vigna di Valle crater and fall deposits from Sacrofano volcano both in the Sabatini volcanic districts were put in place. The volcanoclastic sediments are known in the literature as San Paolo formation, "Conglomerato giallo" unit.

An erosion surface that we relate to isotope stage 10 cuts these sediments. The volcanoclastic and volcanic sequence on it is constituted by fluvial and lagoon sediments interbedded with the "Villa Senni" eruption deposits which include the deposits of two ignimbrites, the "Tufo lionato" and the "Tufo di Villa Senni" ignimbrites, dated at 336 ka, the "Tufo giallo di Sacrofano" from the Sacrofano volcano dated at 333 ka. Toward the top the Capo di Bove lava flow has been recognized. This important lava flow was erupted from the Le Faete edifice, the youngest central volcano of the Colli Albani volcanic District, which grew up inside the collapsed area of the Tuscolano-Artemisio.

The alluvial sediments related to isotope stage 9 are well known as Aurelia Formation (Caloi *et al.* 1998; Conato *et al.* 1980; Malatesta 1978; Malatesta & Zarlenga 1988) and, from a palaeontological point of view, are related to the Torre in Pietra Faunistic Units (F.U.) (Caloi & Palombo 1995), defined in the type section of Torre in Pietra.

Also this succession is closed by an erosion surface related to isotope stage 8 and the following alluvial infill, related to isotope stage 7, is named Vitinia Formation (Conato *et al.* 1980; Caloi *et al.* 1998), which, from a palaeontological point of view, are related to the Vitinia Faunistic Units (FU) (Caloi & Palombo 1995), defined in the type section of Vitinia.

Also this sedimentary cycle is closed by an erosion surface due to the uplift and to the lowering of sea level, on which marine sediments (Tyrrhenian s.s related to the 5e isotope stage, Hearty & Dai Pra 1986; Milli & Zarlenga 1991) are embanked.

After the Tyrrhenian cycle, an unnamed alluvial formation was deposited the Bassa Campagna Romana (with an age corresponding to 0,09 and/or 0,08 and/or 0,05 Ma; Arnoldus-Huyzendveld *et al.* 1993) and lastly the present alluvial bottom valleys, correlated to the Versilian transgression, were formed.

All the volcanoclastic succession, following the Ponte Galeria Formation (l.s.), shows a geometry of overlapping alluvial fills, sensu Leopold *et al.* (1964), that have been interpreted as due to the lack of uplift phase until the Tyrrhenian stage. The sediments of the Tyrrhenian, instead, are embanked at 30-35 m a.s.l. to the older. The rate of this uplift has been calculated to be 10-15m. A second uplift phase of 30 m occurred after the Tyrrhenian, the sediments of the unnamed unit lie at 10-15 m a.s.l. The third and the last uplift phase occurred after the deposition of this and it has been calculated to be of 10 m. This is the cause of the presence of only three main Middle Pleistocene terraces in the "Bassa Campagna Romana".

2. INDUSTRY AND STRATIGRAPHY

During the last thirty years of research the relationships between stratigraphy and human industry has been clarified: In fact we can find Bifacial Acheulean industry in the sediments of the Aurelia Formation, Mousterian in the Vitinia Formation and in the Tyrrhenian or probably younger formations (Saccopastore). This presence, with Mammal fauna and volcanic layers, allow us to define a very good stratigraphy in an area where the outcrops are not so particularly abundant. Lastly it is very important to underline that the sediments which constitute the alluvial fills, represent only a little part of an interglacial stage; in fact, if we observe the present alluvial bottom valleys, we can understand that they were formed during the last arising of the sea level, starting from 12 ka and concluded 8 ka ago c.a.

3. CONCLUSIONS

Several sedimentary cycles were recognized in the "Bassa Campagna Romana" whose age is comprised between oxygen isotope stages 11 and 1. Volcanic deposits from the Tuscolano-Artemisio volcano in the Colli Albani volcanic District and from craters located in the Sabatini volcanic District are interbedded, allowing a correlation between volcanism and sedimentation along the coast. The lack of uplift until the Tyrrhenian stage caused the absence of alluvial terraces and the deposits are instead, alluvial fills insides.

4. REFERENCES

Arnoldus-Huyzendveld, A., Gioia, P., Mussi, M., Toniutti, P., Zampetti, D. & Zarlenga, F. 1993. Paleosuperficie esposta, concentrazione di industria litica e stratigrafia nella piana costiera di Maccarese (Roma). *Il Quaternario*, 6 (2): 213-226.

Caloi, L. & Palombo, M.R. 1994. Biostratigrafia e Paleoecologia delle mammalofaune del Pleistocene medio dell'Italia Centrale. *Studi Geol. Camerti*, B, 503-514.

Caloi, L., Palombo, M.R. & Zarlenga, F. 1998. Late-Middle Pleistocene mammal faunas of Latium (Central Italy): Stratigraphy and environment. *Quaternary International*, 47/48: 77-86.

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

De Rita, D., Milli, S., Rosa, C., Zarlenga, F. & Cavinato, G.P. 1993. Catastrophic eruptions and glacioeustatic episodes in Latium. *Intern. Conf.: "Large explosive eruptions". Accademia Nazionale dei Lincei, 25/5/93, Rome*.

Fisher, R.V. & Schmincke, H.U. 1984. *Pyroclastic rocks*. Berlin: Springer-Verlag.

Hearty, P.J. & Dai Pra, G. 1986. Aminostratigraphy of Quaternary Marine deposits in the Lazio Region of Central Italy. *Zeit.Geomrph.N.F.*, 62: 131-140.

Karner, D.B., Marra, F., Renne, P., Alvarez, W. & Ammerman, A.J. 1994. ^{40}Ar/^{39}Ar dating of complex coastal deposits in Italy : a radiometric calibration of Pleistocene climate cycles. *Congr. Geol. Am. Soc., 20-22 Oct., Seattle*.

Leopold, L.B., Wollman, M.G. and Miller, J.P. 1964. *Fluvial processes in geomorphology*. San Francisco and London: Freeman W.H.

& Company.

Malatesta, A. 1978. Torre in Pietra. Roma. *Quaternaria* 20: 203-577.

Malatesta, A. & Zarlenga, F. 1988. Evidence of Middle Pleistocene transgression along Mediterranean Coast. *Palaeogeogr., Paleoclim., Paleoecol.* 68: 311-315.

Marra, F. & Rosa, C. 1995. Stratigrafia e assetto geologico dell'area romana. *Mem. Descr. Carta Geol. d'It.* 50: 49-118.

Milli, S. 1992. Analisi di facies e ciclostratigrafia in depositi di piana costiera e marina marginali. Un esempio nel Pleistocene del Bacino Romano. *Tesi di dottorato di Ricerca, IV ciclo*, Università degli Studi di Roma "La Sapienza", Roma.

Milli, S. & Zarlenga, F. 1991. Analisi di facies dei depositi tirreniani (Duna Rossa) affioranti nell'area di Castelporziano (Roma). Una revisione ambientale. *Il Quaternario* 4 (1b): 233-248.

Middle and Upper Pleistocene natural environment in the Roman area: climate, vegetation and landscape

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SUMMARY: The natural environment of the Rome area is outlined by the palaeobotanical and palynological studies from the diatomite deposit of Riano Romano and by the long pollen sequence of Valle di Castiglione near Rome. The middle and upper Pleistocene climatic and vegetational fluctuations recorded in Latium highlight a considerable variety of landscapes, compared to what is known in other European countries. Even within Latium, it is possible to recognize different floristic and vegetational features through correlation of the various studied sites, responding with an exceptional sensitivity to the diversity of the environmental situations typical of the ecological ecotone of the region.

1. FOSSIL PLANTS AT RIANO ROMANO

One of the most important palaeobotanical and palynological sites studied in relation to fossil elephants in Latium is the diatomite deposit of Riano Romano, where a wealth of fossil leaves, seeds and fruits, coupled with pollen analysis, revealed the existence of a lush forest, dominated by *Pterocarya fraxinifolia* (Follieri 1958, 1962). No other natural archive has been discovered in Italy with floristic and vegetational characters so similar to the forest currently occupying the plains of the Caucasian region between the Black Sea and the Caspian Sea. The landscape at Riano Romano was characterized by a very dense forest, interrupted by marshes and wide lacustrine basins, with a remarkable plant biodiversity compared to the coeval records of vegetation in central and northern Europe. The modern analog of this landscape may be found in areas with over 2000 mm mean annual precipitation, favouring the development of such a dense forest that only few plants can grow in the darkness under the canopy.

The Colchic forest represented in the pollen analysis of Riano Romano, dated to approx. 300 Ka Bp by fission tracks and by K/Ar measurements, shows three forest phases with different floristic composition: a mixed oak forest at the basis, followed by a period with dominant *Pterocarya* and by a final phase with *Carpinus* and *Abies*. The arboreal pollen is always more abundant than the non-arboreal pollen, confirming the picture provided by the macrofossils, indicating the local presence of some thirty woody taxa currently living in the coastal areas of Georgia, facing the Black Sea. Some of them are Tertiary relicts, like *Pterocarya* and *Zelkova*, accompanying various species of maples, ashes, limes, hornbeams, living together with *Fagus sylvatica, Abies alba, Ilex aquifolium, Vitis vinifera* and *Hedera helix* (Fig. 1).

2. THE POLLEN RECORD OF VALLE DI CASTIGLIONE

The long pollen sequence from Valle di Castiglione, an artificially dried out crater lake near Rome, is a chronostratigraphical and palaeoenvironmental foundation of the Campagna Romana for the whole time interval of the last 250,000 years (Fig. 2).

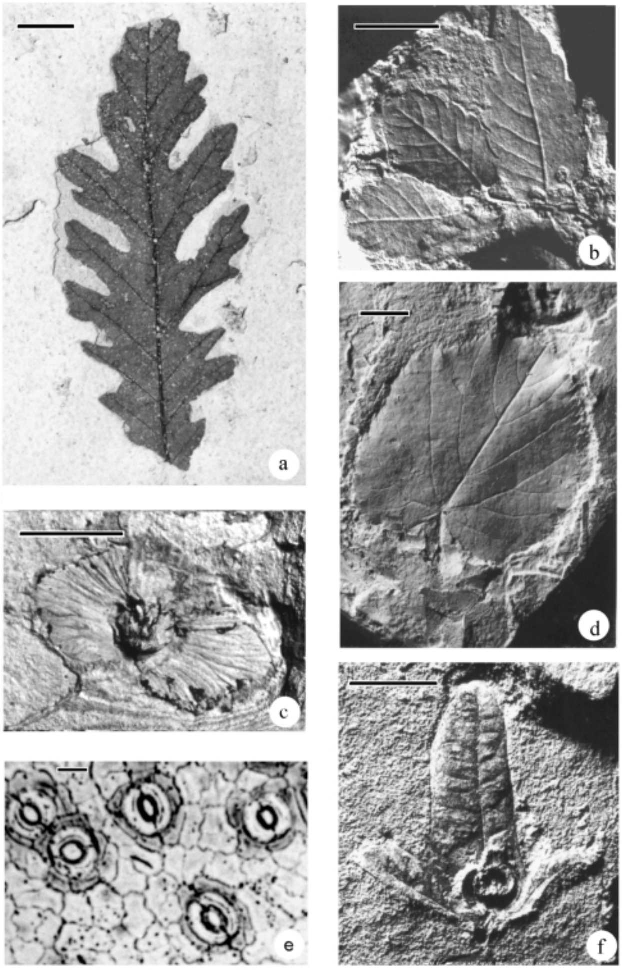

Fig.1 - Riano Romano. Fossil leaves and fruits from the diatomite (approx. 300,000 BP): a) leaf of *Quercus cerris* L., b) leaf impressions of *Zelkova crenata* Spach., c) winged fruit of *Pterocarya caucasica* C. A. Mey., d) leaf impression of *Tilia cordata* Mill., e) cuticle of *Ilex aquifolium* L., f) fruit of *Carpinus betulus* L. - In e) the scale bar corresponds to 20 µm; in the other pictures the scale bar is 1 cm.

This exceptional record of the floristic, vegetational, climatic, biostratigraphical, palaeoecological characters of the region allows a detailed reconstruction of the events occurred during two complete interglacial-glacial cycles (Follieri *et al.* 1988). The chronology of the sequence has been estimated on the basis of a number of radiocarbon dates, counts of annual laminations in the sediments, comparison with marine oxygen isotope curves, synchronization with the precession of equinoxes.

The late Quaternary landscapes of the Rome area may be described by two general vegetation types, alternating in response to the frequent climatic fluctuations: a forest-dominated type, and an open vegetation type, characterized by steppes and grasslands, particularly important during the glacial phases of the Pleistocene. The open formations are the commonest vegetation types, interrupted by relatively short forest phases. In fact the pollen record from Valle di Castiglione indicates that, during the last quarter of million of years, only in 1/10 of the time are the percentages of arboreal pollen higher than 80%, a value indicating true forested situations. Grasslands with reduced arboreal component characterize the most frequent landscape of the Campagna

Romana, while the diffusion of forest communities occurred only in specific climatic conditions, similar to the present ones.

The floristic composition of the forest phases recorded in the sediments of Valle di Castiglione is substantially different from that of central and northern Europe. The various vegetational phases are clearly distinct from one another on the basis of their floristic composition, presence of taxa in extinction and dominant trees (Follieri & Magri 1998). For example, the forest phases Roma I and Roma II, corresponding to marine oxygen isotope stages 7e and 7d respectively, show the presence of *Pterocarya*, but with *Carpinus* dominant in the first case and *Fagus* dominant in the second.

During the Eemian (broadly corresponding to oxygen isotope stage 5e) *Pterocarya* is absent, but *Zelkova* shows a remarkable expansion, in a woodland dominated by evergreen oaks. On the whole, the Mediterranean component of the vegetation is more abundant during the Eemian than during the Holocene.

In the following forest phase, St Germain I, correlated with oxygen isotope stage 5d, the highest percentages of deciduous oaks are found, but beech and fir are also abundant.

The vegetational features of the Valle di Castiglione pollen record enable a number of general remarks to be made towards a first palaeoclimatic interpretation. The most schematic form of representation of the past vegetation is provided by the Arboreal Pollen (AP) percentage (Fig. 2) indicating the physiognomic character of the vegetation that is the most general and understandable: its structure. This can provide a first indication of the gereral wetness of the climate: the forest phase corresponding to St Germain I, with an average AP percentage of 90%, has the features of a wet phase, whereas the open vegetation period between St Germain I and St Germain II (20% AP) represents arid conditions. Further climatic information may be obtained from an analysis of the vegetation composition: the differentiation of the forest vegetation into Mediterranean, submontane and montane, according to the present-day geographical distribution, corresponds in fact to a rough distinction of climatic features. Mediterranean vegetation bears summer dryness, but not excessive winter cold. Submontane and montane forest vegetation, with prevalent deciduous trees, instead needs summer wetness – greater for the montane belt - and tolerates cool winters. The simultaneous presence of the three types of forest vegetation, which in the past could live, as today, at different elevations, indicates that when the moisture conditions remained such as to permit the trees to live, the temperature conditions were mainly suitable both for Mediterranean vegetation and for submontane as well as for montane vegetation. All the same, the prevalence of the one type of vegetation or the other testifies that during the various forst phases differences occurred in the seasonal distribution of the temperatures and of precipitation. Thus the climate of the Eemian, with prevalent Mediterranean vegetation, must have been characterized by mild, rainy winters and dry summers; the climate of Roma II and St Germain I, typified by montane vegetation and by the maximum peaks of concentration, must have been characterized by considerable general wetness, with abundant rains in the summer as well.

3. THE LAST GLACIAL

The last glacial vegetation is relatively well known in the Lazio region, on the basis of five long pollen records, which can be clearly correlated by radiometric dates and pollen biostratigraphic characters (Follieri *et al.* 1998): Valle di Castiglione (Follieri *et al.* 1988, 1989), Lagaccione (Magri 1999), Lago di Vico (Magri & Sadori 1999), Stracciacappa (Giardini 1993) and Valle di Baccano (Ciuffarella 1996).

The history of vegetation indicates that this region, which at present shows the characters of an ecotone, was particularly sensitive to the weak climatic fluctuations of the last glacial, inducing repeated and sometimes significant diffusions of trees. The region was a privileged area for the survival of thermophilous and mesophilous trees during the whole glacial period, even when extensive ice sheets covered central and northern Europe.

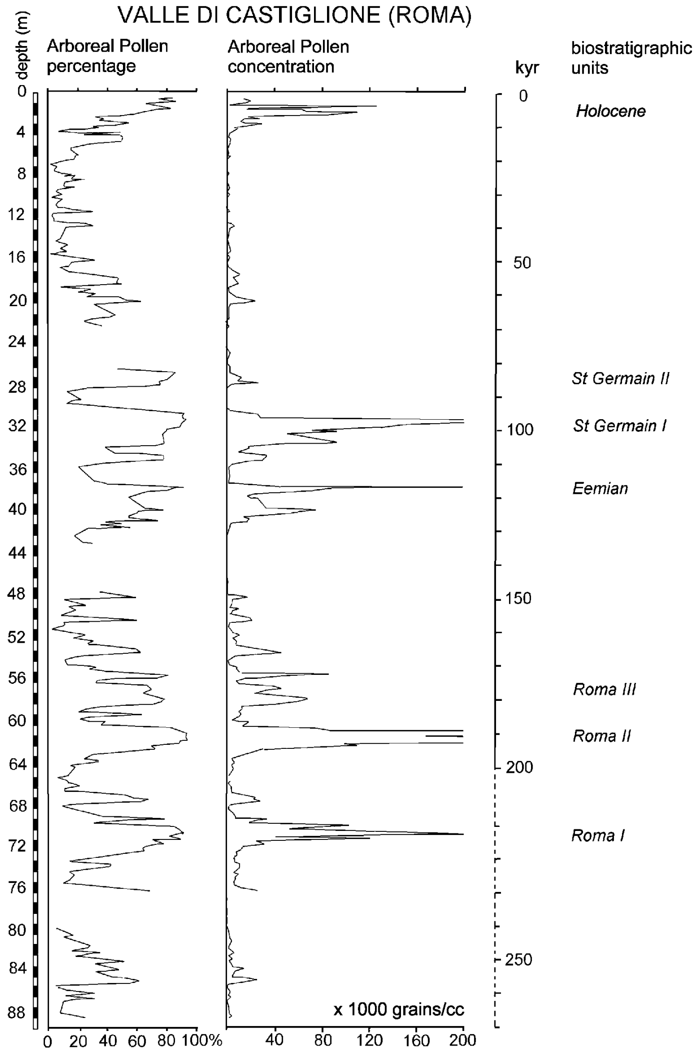

Fig.2 - Synthetic pollen diagram from Valle di Castiglione (modified after Follieri *et al.* 1988).

The considerable length and continuity of these pollen records have made it possible to follow the history of many arboreal taxa in the region. Some tree taxa (e.g. *Abies*) are found at all the sites at the same time; they can be used to characterize the forest periods at a regional scale. Other taxa (e.g. *Fagus*) display locally different behaviour in the various sequences. Some other taxa (e.g. *Picea*), not living any more in Latium, are found in the pollen records only for limited time intervals. It clearly appears that the pollen data from the long records of the region make it possible to characterize the various biostratigraphic units on the basis of the floristic features, and to distinguish regional and local aspects of the vegetation (Follieri *et al.* 1998).

4. CONCLUSION

The Quaternary environments of the Rome area are described in considerable detail by the palaeobotanical and palynological studies carried out in the region, contributing in a substantial way to the palaeontological, geomorphological and lithostratigraphical investigations. In fact the palaeobotanical data provide not only a reconstruction of the floristic and vegetational features, but also of important palaeoecological and palaeoclimatic details in a well-defined chronological framework obtained from continuous records.

5. REFERENCES

Ciuffarella, L. 1996. *Studio palinologico di una lunga sequenza di Valle di Baccano (Complesso vulcanico Sabatino, Italia centrale). Tesi di Dottorato in Scienze Botaniche*. Roma: Università degli Studi di Roma "La Sapienza".

Follieri, M. 1958. La foresta colchica fossile di Riano Romano. I. Studio dei fossili vegetali macroscopici. *Annali di Botanica,* 26: 129-142.

Follieri, M. 1962. La foresta colchica fossile di Riano Romano. II. Analisi polliniche. *Annali di Botanica,* 27: 245-280.

Follieri, M., Giardini, M., Magri, D. & Sadori, L. 1998. Palynostratigraphy of the last glacial period in the volcanic region of central Italy. *Quaternary International,* 47/48: 3-20.

Follieri, M. & Magri, D. 1998. Paesaggi vegetali del Quaternario in Italia centrale. *Biogeographia,* 19 (1997): 57-68.

Follieri, M., Magri, D. & Sadori, L. 1988. 250,000-year pollen record from Valle di Castiglione (Roma). *Pollen et Spores,* 30: 329-356.

Follieri, M., Magri, D. & Sadori, L. 1989. Pollen stratigraphical synthesis from Valle di Castiglione (Roma). *Quaternary International,* 3/4: 81-84.

Giardini, M. 1993. Late Pleistocene and Holocene history of vegetation at Stracciacappa, Monti Sabatini volcanic district (Central Italy). Abstracts of the INQUA-SEQS Symposium "Quaternary Stratigraphy in Volcanic Areas" Rome, September 20-22, 1993: 34.

Magri, D. 1999. Late Quaternary vegetation history at Lagaccione near Lago di Bolsena (central Italy). *Review of Palaeobotany and Palynology,* 106: 171-208.

Magri, D. & Sadori, L. 1999. Late Pleistocene and Holocene pollen stratigraphy at Lago di Vico, central Italy. *Vegetation History and Archaeobotany,* 8: 247-260.

The World of Elephants - International Congress, Rome 2001

General geological features of the Campagna Romana

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SUMMARY: The paleogeographic evolution of the Campagna Romana is presented as an integrated study of subsurface structural features and lithostratigraphy of superficial outcrops within the Roman suburbs. Outcropping units were developed from differentiated environmental conditions, from marine Plio-Pleistocene clayey and sandy deposits to continental Middle to Upper Pleistocene shales and conglomerates. Since the Matuyama-Brunhes magnetic reversal until Holocene, huge volumes of volcanic products were emitted by two volcanic Districts, located NW (Sabatini Mts) and SE (Alban Hills) of Roma.

1. PALEOGEOGRAPHIC EVOLUTION

The area of the Campagna Romana is extended along the western coast of Central Italian Peninsula, between the Apennine chain and the Tyrrhenian Sea. The Apennine is a complex structural unit mainly thrusted toward SE and recently extended in the western sector were, from Tuscan area to Neapolitan region and Southern Tyrrhenian sea, an alkaline potassic volcanic back-ark province was developed from lower Pleistocene to actual time.

The large and subplanar region of Roma, Latium, shows a landscape mainly linked to the Quaternary tectonic evolution of the Tyrrhenian Apennine boundary, with six main volcanic districts lying in a extensional plain surrounded by several Plio-Quaternary marine to continental units. A peculiar Holocene geomorphological unit of the Tevere river crosses the Latian region and characterize the coastal area with a deltaic area, which had an important role in the history of Roma.

The specific deep structure of the Campagna Romana is made by a main extensional structure, mainly founded on previous NW-SE thrust marine Meso-Cenozoic units with basin to shelf carbonate meso-cenozoic facies.

The graben-like structure is filled by Plio-Pleistocene marine deposits, continental Upper Pleistocene sediments and Sabatini Mts and Alban Hills volcanic products. The sedimentary sequence, from the bottom to the top, is composed by a thetysian “ligure” basal unit organized in a sequence of ramp and flat structure thrusted by a Tuscan basin mesocenozoic structures, uprising a maximum of few hundred of meters below the surface in correspondence with structural highs (Cristoforo Colombo, GRA) or in Cesano (1300 m below the surface) in correspondence with a ramp-like structure, filled by an irregular mantle of Plio-Pleistocene marly clays that represent a sort of impervious continuous cover.

The Plio-Pleistocene marine cover reaches the boundary of the Apennine chain and outcrops in correspondence of structural highs, previous inheritance of deep ramps still present at surface level also within the city of Roma (Monte Mario, Monte Ciocci and Monte delle Piche units). A complex pattern of regional structural units controls the different outcrops of these sediments, finally influencing the geomorphological pattern of the area. In figure 1 the interaction between the deep gravimetric structural pattern (Toro 1976) and superficial landscape is shown. Distribution and activity of volcanoes, surface and deep hydrogeology, transmission of seismic energy, landscape geomorphological evolution, features connected with paleoenvironment evolution are mainly due to the deep structural pattern. Connections among tectonic activity, climatic and paleogeographic changes related to the glacial and interglacial periods produced a complex transgressive cycle characterized by the alternation of deposition and erosional phases.

After the Matuyama-Brunhes magnetic reversal, Sabatini Mts and Alban Hills volcanic districts were developed NE and south of Roma. Regional extensional and transtensional tectonic produced an intense activity, mainly explosive, with a volume of volcanics ranging between 500 and 1000 km^3. These events deeply modified landscapes and environment, hydrology and hydrogeology of the area of Roma.

A relevant regression of the sea level accelerated the erosional processes of the Tevere river excavating the Pliocene bedrock more than 60 meters below sea level. During the subsequent rise of the sea level, the articulated network excavate by the Tevere river and its tributaries was filled with alluvial Holocene deposits, consisting of unconsolidated clayey-sandy sediments.

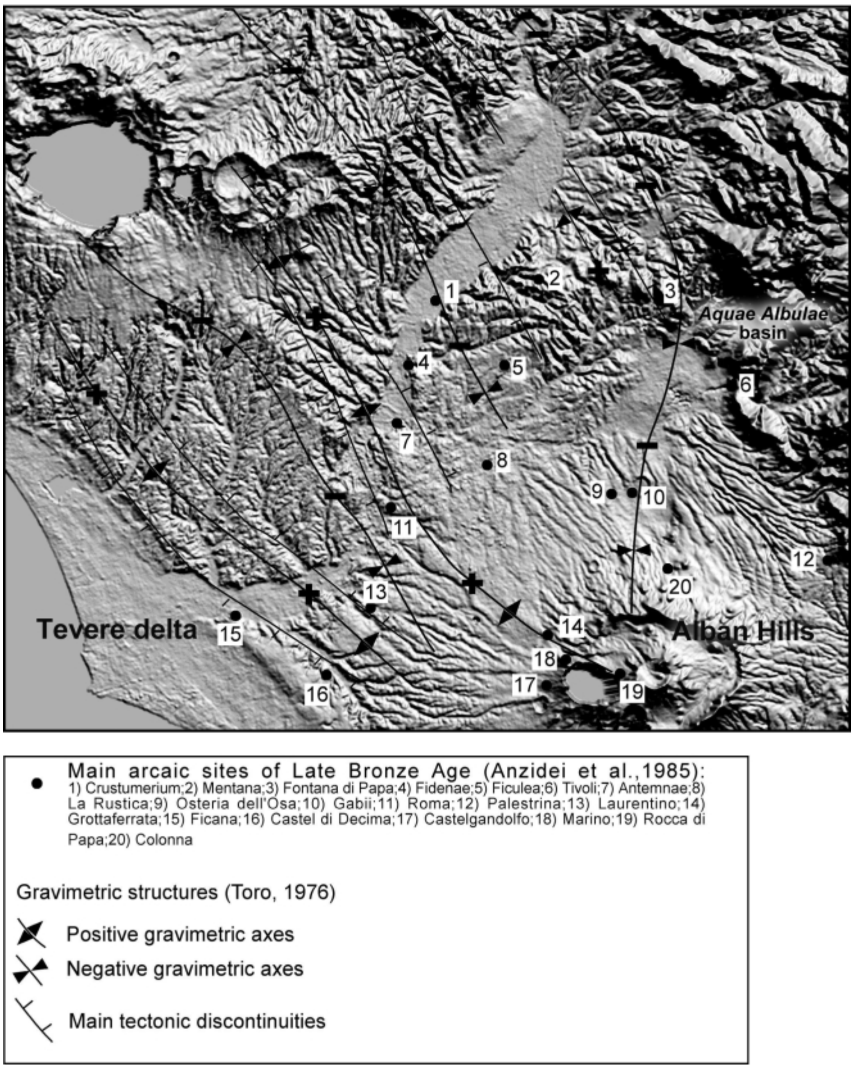

Fig.1 - Landscape of the Campagna Romana, with the main gravimetric features and the Late Bronze Age sites.

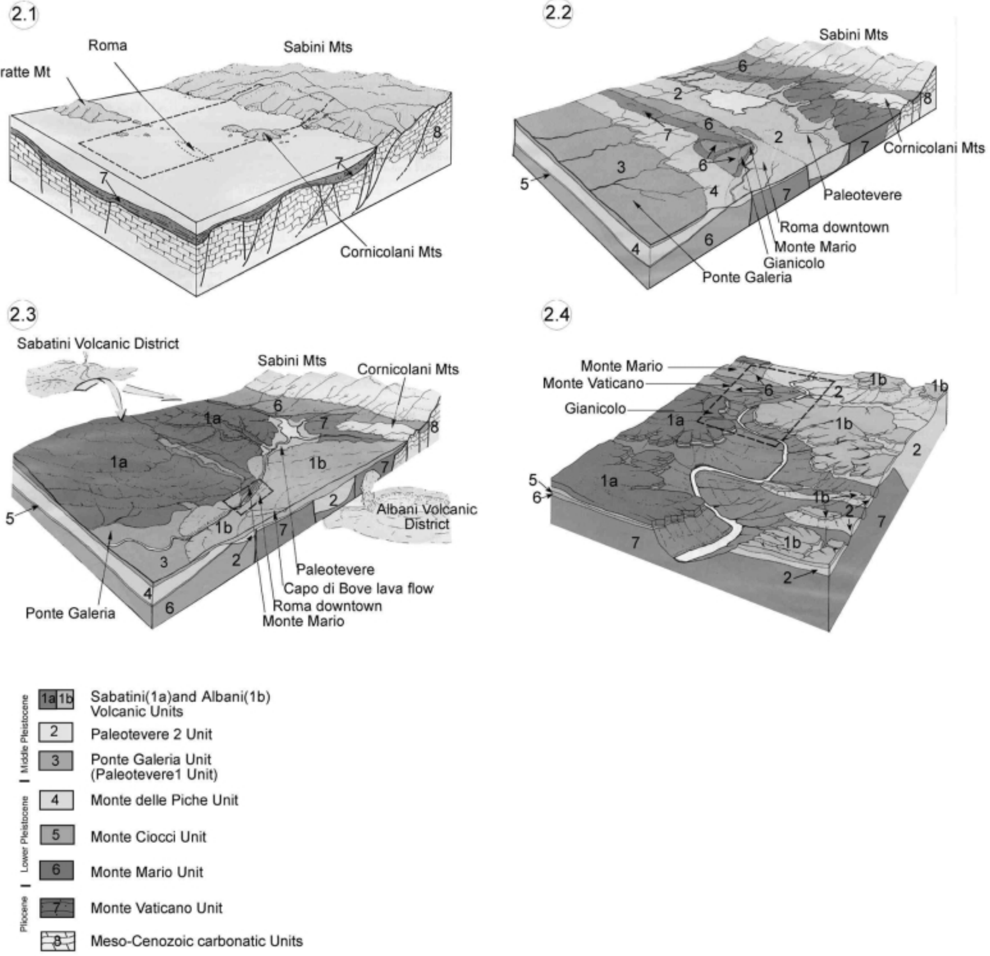

Fig.2 - Paleogeographic evolution of the Campagna Romana.

Figures 2 and 3 show to the main paleogeographic events of the Campagna Romana and landscape evolution since Upper Pliocene (the dashed squares in figures indicate the successive steps of the paleogeographic evolution).

- 2.1) The sea was reaching the border of the Apennine chain; a thick sedimentary clay to marly clay unit was deposited in a wide area corresponding to what will become the Campagna Romana. The structural relieves of Soratte Mt. and Cornicolani Mts were small islands NW-SE trending; from the future Monte Mario toward the future Roma downtown area, a shallow marine environment was developed.
- 2.2) The relief of Monte Mario came out from a wide sedimentary cover of sandy-gravelly deposits which was giving rise to the coastal belt. The ancient course of the Tevere river had its mouth to the South of the present position.
- 2.3) Extent of Alban Hills and Sabatini Mts volcanic products, mainly ignimbrites, and modification of the drainage pattern of the Tevere river.
- 2.4) Geomorphological and geological sketch of the Roma area during last low stand of sea level and deep erosion of the hydrogeological network of the Tevere river, confined in the present-day river bed. The relics of the volcanic plateau represent the present day eastern topographic relieves of Roma.
- 3) The Tevere valley was delimited at the

western margin by the Monte-Mario-Gianicolo ridge, and, in the eastern portion of the town, by the relics of the volcanic plateau, the famous Seven Hills of Roma. During the Holocene high stand of sea level, the recent alluvium filled the deep valley excavated by the Tevere river during the Wurmian glacial period. (A= recent alluvial deposits of Tevere river and its tributaries; for other symbols see Fig. 2).

2. HOLOCENE DEPOSITS AND FINAL CONSIDERATIONS

Three peculiar geological features were developed in the Roma area until Holocene with a rapid continuous evolution: the Acque Albule hydrothermal basin, the Tevere river delta and a flat area northward of the Albano lake (Fig. 1).

These quite contemporaneous features are obviously deeply different in origin as a function of different location and influence on the surrounding environment. The landscape of these features is always flat in a sharp morphological contrast with the Pleistocene morphology of surrounding areas of the Campagna Romana.

The Acque Albule basin is a tectonic depression 30 km^2 large where thermomineral springs and travertine depositional processes are still active. Radiometric analyses (^{230}Th/^{234}U) indicate that the travertine began to deposit around 165 ka ago. The uppermost travertine deposit so called “cappellaccio” began its deposition earlier than 40 ka ago. Actually the travertine is still in active deposition by means of huge thermomineral springs upwelling with a flow of more than 4m^3/s with an average speed of 0.43 mm/a.

The Tevere delta accreted for long time. The evolutive deltaic cycle began with the last eustatic sea level rise and the river mouth position was migrated 10 km westward in the last 18 ka. Impressive geomorphological changes were penecontemporaneous to the protostoric and historic evolution of the area. Lagoonal and sandy islands environments were developed

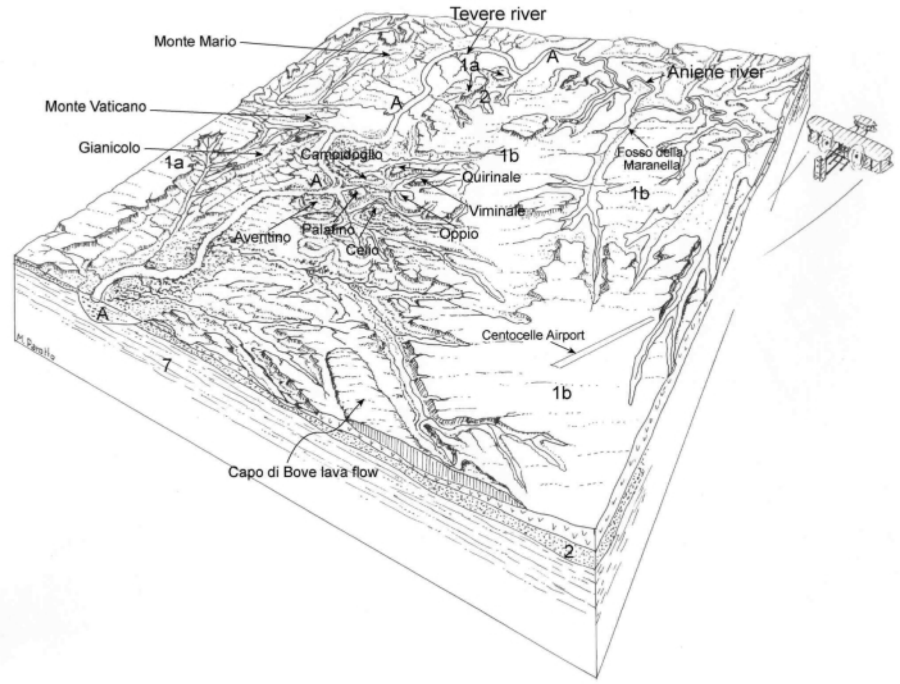

Fig.3 - Present natural landscape of the Roma area.

along the coastline 3000 years ago. Being the sea level quite stable the lagoon was filled with Tevere river deposits, consequently the lagoon-delta body rapidly prograded towards the bar. During the imperial times two main lagoons were isolated from the river. The positions of the Claudius and Trajanus harbours and their artificial canals gave rise the present mouth of Fiumicino. Anywere the Tevere river has built up its delta in the last 2000 years prograding 6 km toward the Tyrrhenian sea.

A third flat Holocene area was created northward of Albano lake within the western sector of the Alban Hills volcanic district. It was mainly connected with the limnopalustrian deposits produced by the lake positive movements and flowing. The possible connection with late endogenous activity or climatic crisis is still debated and studied. Development of the arcaic cultures until roman times seems to be influenced by this peculiar feature.

The continuous link among deep structural features, surface distribution of geological units, landscape of the Campagna Romana, distribution of sites of human settlement from Stone Age to historical times and important Quaternary fossil mammals rich outcrops seems to be clear. It seems to be mainly following the influences and restrictions of the continuos evolution of the environmental condition and also depending from some catastrophic event connected with volcanic, tectonic or hydrometeorological conditions.

3. REFERENCES

Ambrosetti, P & Bonadonna, F.P 1967. Revisione dei dati sul Plio-Pleistocene di Roma. *Atti Accademia Gioenia di sc:nat.in Catania* 18: 33-70.

Anzidei, A.P., Bietti Sestieri, A.M., Desanctis, A. 1985. Roma e il Lazio dall'Età della Pietra alla Formazione della città. In *Archeologia e Storia di Roma*. Ed. Quasar.

Bellotti, P., Caputo, C., Ciccacci, S., De Rita, D., Donati, S., Fredi, P., Funiciello, R., La Monica, G.B., Landini, B., Marra, F., Milli, S., Parotto, M., Pugliese, F. 1997. Fundaments for a geomorphological overview on Roma and its surroundings. *Suppl Geogr. Fis. e Dinamica Quat.,* Suppl. III, 2: 105-121.

Di Filippo, Toro, B. 1980. Analisi gravimetrica delle strutture geologiche del Lazio meridionale. *Geologica Romana* 19: 285-294.

Donati, S., Funiciello, R., Rovelli, A. 1998. Seismic response in archeological areas: the case histories of Rome. *Journal of Applied Geophysics* 41: 229-239.

Faccenna, C., Funiciello, R., Montone, P., Parotto, M., Voltaggio, M. 1994. Late Pleistocene strike-slip tectonics in the Acque Albule Basin (Tivoli, Latium). *Memorie Descrittive della Carta Geologica d'Italia* 49: 37-50.

Funiciello, R., Rovelli, A. 1998. Terremoti e Monumenti in Roma. *Le Scienze* 357: 42-49

Locardi, E., Lombardi, G., Funiciello, R., Parotto, M. 1977. The main volcanic groups of Latium (Italy): relations between structural evolution and petrogenesis. *Geologica Romana* 15: 279-300.

Marra, F., Rosa, C., De Rita, D., Funiciello, R. 1998. Stratigraphic and tectonic features of the middle Pleistocene sedimentary and volcanic deposits in the area of Rome (Italy). *Quaternary International* 47/48: 51-63.

Toro, B. 1976. Gravimetry and deep structure of the sabatinian and alban volcanic area (Latium). *Geologica Romana* 15: 301-310.

The Elephants at the Leonardo Da Vinci Institute in Rome

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SUMMARY: The Leonardo Da Vinci Technical Institute of Rome, founded in 1871, has a collection of mammal fossils typical of the Middle to Late Pleistocene period which were found mostly in areas in and around Roma. The majority of the items in this collection are the remains of *Elephas (Palaeodoxodon) antiquus* Falconer & Cautley, 1847, including two large tusks, one of which may be part of the cranium found during the construction of the Via Fori Imperali, of which all trace has been lost and which was described in great detail by De Angelis D'Ossat (1932). The presence of this rich natural science collection documents the constant and continuous contact that the institute had with the University of Rome and numerous other Research Institutes between the end of the 1800's and the beginning of the 1900's.

1. INTRODUCTION

The Leonardo da Vinci Institute is one of Rome's oldest schools. It was founded in 1871 on the German model of technical schools, under the authority of the Ministry of Agriculture. It consisted of four areas of study, two of which prepared students for entry into the University Faculties of Mathematics and Engineering. The study of Natural Sciences was considered important and was studied in depth, theory was supported by practice and experimental study (the students went fossil hunting and collected fossils and minerals in the Roman countryside. Collections acquired from prestigious Institutions and donations from private collectors and scholars were added to these finds). For this reason in the store-rooms of the school there are important exhibits, some of which are unknown even to the specialists. Among them there is a collection of vertebrate fossil remains, the most important examples of which are without doubt the remains of *Elephas antiquus* coming from the Roman countryside as the labels attached to some pieces lead us to believe.

2. THE ELEPHANT SAMPLES

The elephant samples, sometimes associated with the scanty remains of Middle to Late Pleistocene mammalians such as *Bos primigenius, Hippopotamus amphibious* and *Cervus elaphus* are mostly from sites in what are now urban areas of Rome.

2.1 Monte Sacro

These remains are from volcanoclastic deposits found in this area, finds which date back to the end of the 1800's such as: a fragment of a tusk accompanied by a label signed by the scholar Mantovani, which reads: " Fragment of a gigantic tusk found in the Pleistocene clay mass of Monte Sacro, Rome: Right bank of the Aniene River"; a distal epiphysis of a femur of *Bos primigenius* (170mm long and 160mm maximum width) accompanied by a label that reads: "Inferior articulation cap of the femur of *Bos primigenius* found in the silt of the valley of the Aniene River. Monte Sacro on the Via Nomentana 4 km from Rome. Acquired by Clerici 1884"; the right tusk of *Elephas antiquus* (Fig. 1) as deduced by the identical matrix on both the tusk and on the articulation cap of the femur of *Bos primigenius* (accompanied by a dated label).

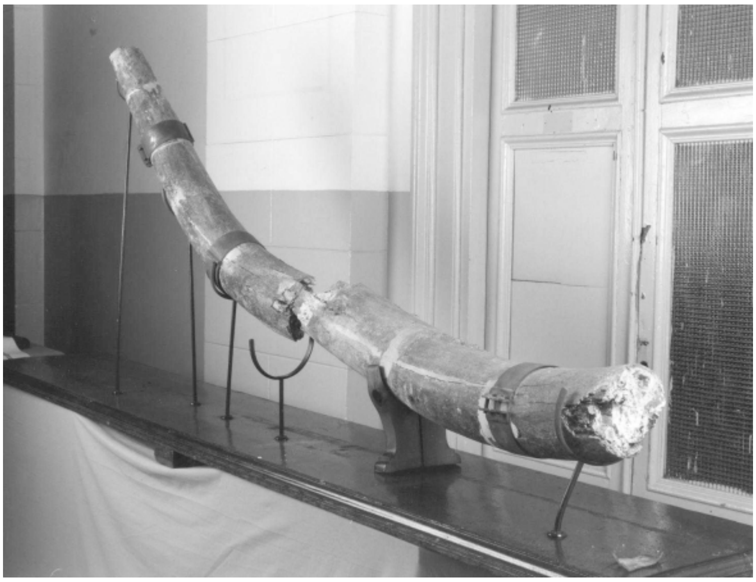

Fig.1 - The right tusk – Monte Sacro, Roma.

2.2 "Via dei Fori Imperali" Site in the area of the Temple of Venus, and the area of the "Chiesa dei Santi Luca e Martina"

The excavations in Via dell'Impero, today known as Via dei Fori Imperali, led to the finding of numerous specimens of *Elephas antiquus* (De Angelis D'Ossat 1932; Maccagno 1962).

The left tusk conserved at the Leonardo Da Vinci Institute is almost certainly from the cranium found during the excavations in 1932 and described in detail by De Angelis D'Ossat. Much data confirms this theory: its morphology, the external length from the alveolus to the apex (2450mm) and the diameter at the height of the mandible (approximately 200mm), its state of preservation also corresponds exactly to the measurements and description written by De Angelis D'Ossat. In the photograph taken at the time of the find there is also the cranium (Fig. 2) that is now probably to be found in the Musei Capitolini (Maccagno 1962) even though we cannot exclude that it has been lost, since De Angelis D'Ossat himself underlined its extremely fragile state.

This tusk is also fractured and one notes the clumsy attempt to reconstruct it, even utilising common cement (Fig. 3). This agrees well with De Angelis D'Ossat's observations according to which the tusk, after having been summarily consolidated in loco, was quickly removed and taken away by Dr Clini to the Municipal Antiquarium (in the Celio district near the Chiesa di San Gregorio), where minor archaeological finds were deposited. No tusk appears to be present among the fossil remains of the Antiquarium currently housed in the Museo della Civiltà Romana.

A mandible can also be traced to the same find with the last molars in place that corresponds to the illustrations and description of De Angelis D'Ossat. For the other remains (acetabulum and some molars of *Elephas antiquus*) one could hypothesise their provenance from the fluvio-lacustrine deposits lying above the volcanic outcrop along the western side of the Chiesa dei Santi Luca e Martina adjacent to the Campidoglio

Finally it must be said that in the Institute there are, as well as the remains of Elephas antiuus, finds of *Bos primigenius* and *Cervus elaphus* which were also found during the excavations of the Via dei Fori Imperali.

2.3 Carini Site (Palermo, Sicily)

The Institute's collection also includes a tusk from *Elephas mnadriensis* (Fig. 4) which was

Fig.2 - Tusk and cranium found during the excavations in via dei Fori Imperiali (1932).

donated to the school as the label reads: “Donation from P Gallegra 1885. Tusk found about 2 kilometres from the village of Carini (in the environs of Palermo, Sicily)”. The presence of this specimen leads us to believe that in the Institute at the end of the 1800’s there was a lively interest in the study of vertebrate fossils, and in particular of elephants.

3. REMARKS

Between the end of the 1800’s and the beginning of the 1900’s the Leonardo Da Vinci technical Institute was a true “Research Institute” as its many important natural science exhibits testify (fossils, minerals, marble, rocks etc) and it also had close contact with University Institutions. These contacts we can deduce from the labels accompanying many samples, documentation in the archives, from the description of the scientific experiences described in the annals of the Institute and also from the plaster casts of two ichthyosaurs, the originals of which are to be found in the Museo di Paleontologia of Università degli studi di Roma “La Sapienza”. We must not forget that here at the Institute there was a department of study for preparation for entry into the Faculty of Engineering.

Fig.3 - *Elephas antiquus* tusk – via Fori Imperiali – Roma.

Fig.4 - *Elephas mnadriensis* tusk – Carini, Palermo.

5. REFERENCES

De Angelis D’Ossat, G. 1930. Il sottosuolo dei fori romani e l’*Elephas antiquus* di Via dell’ Impero. *Bull. Archeol. Comun.*, 63, 43p., 17f., 4pl.

De Angelis D’Ossat, G. 1933. Mammiferi fossili recentemente rinvenuti nel Lazio. *Atti della Pontificia Accademia delle Scienze Nuovi Lincei*, sessione II del 15 gennaio 1933, 86.

Maccagno, A.M. 1962. Gli elefanti fossili di Riano. *Geologica Romana* 1: 33-132.

Seeing use-wear on the “oldest tools”: La Polledrara di Cecanibbio and Casal de’ Pazzi (Rome)

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SUMMARY: The preliminary results of the functional analysis of the less alterated tools from the two Lower-Palaeolithic sites of La Polledrara di Cecanibbio (Rome) et from Casal de’ Pazzi (Rome) are shown. The analysis combines three methods of microscopic observation to reach the most detailed view of the micro-modifications occurred to the tools surface by use and by post-depositional agents of alteration: the low-power approach with a reflecting light stereomicroscope, the high-power approach with a reflecting light metallografic microscope and the electron scanning microscope (SEM) approach.

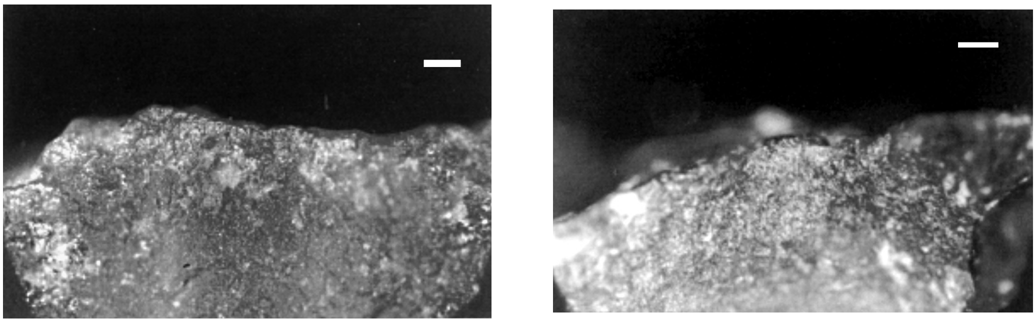
Functional studies related to the use-wear analysis of Lower Palaeolithic industries present strong limitations due to the usually bad state of preservation of the artefacts’ surface. Post-depositional events affecting so old anthropic deposits make often impossible to apply use-wear analysis to very patinated assemblages.

No much longer than a decade ago, more and more researchers began, for this reason, to integrate different methods of microscopic analysis of lithic surfaces with the valuation of macro- and micro-traces by means of a reflecting light stereomicroscope, a reflecting light metallographic microscope, and electron scanning microscope (SEM). This diversified approach increased the interpretative possibilities of this kind of analysis, making it possible to advance functional hypothesis even for very old contexts, and to add new data with regard to the procedures of post-depositional alteration of lithic assemblages (van Gijn 1989; Longo 1994; Márquez *et al.* 1999; Silvestrini *et al.* in publication).

As far as the two Lower Palaeolithic famous contexts near Rome of Polledrara di Cecanibbio and Casal de Pazzi are concerned, a first check was done about the potentials of the electron scanning microscope for the functional estimation of the two lithic industries, which, in turn, present a very bad state of preservation, due to more or less developed phenomena of fluitation.

Both the natural lithic surfaces and the use-wear traces of used experimental artefacts have been analysed by SEM, so that it was possible to obtain several data, useful for the observation and the interpretation of lithic surfaces of archaeological artefacts sampled among the less patinated.

It is to be emphasised here that, as far as the Polledrara di Cecanibbio site is concerned, in the recent past it was possible to formulate detailed hypothesis about the functional analysis of some ten artefacts coming from a limited area in the western part of the excavation with an excellent state of preservation (Anzidei *et al.* 1999: 180-183). As a matter of fact, it was possible, by means of a reflecting light stereomicroscope and a metallographic microscope, to identify macro- and micro-wears related to the wood carving and carcasses butchering (Figs. 1, 2), which, in one case at least, was surely carried out by hands, as testified by the traces of an hand friction on the tool surface.



Figs. 1, 2 - Fleshy tissue polishes (butchering activity); all scale bars equal 50 µm.

REFERENCES

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Palombo, M.R. 1999. Two middle pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia – Casal de' Pazzi. In *The role of early humans in the accumulation of European Lower and Middle Palaeolithic bone assemblages*. Monographien des Römisch-Germanischen Zentralmuseums 42. Mainz: 173-195.

Gijn van, A. 1989 A functional analysis of the Belvédère flints. In W. Roebroeks, From find scatters to early hominid behaviour. A study of Middle Paleolithic riverside settlements at Maastrich-Belvédère (The Netherlands). *Analecta Praehistorica Leidensia*, 21: 125-132.

Longo, L. 1994. L'industria litica. L'analisi delle tracce d'uso. In C. Peretto (ed.), *Le industrie litiche del giacimento paleolitico di Isernia La Pineta. La tipologia, le tracce di utilizzazione, la sperimentazione*: 355-466. Campobasso: Istituto Regionale per gli Studi del Molise "V. Cuoco".

Márquez, B., Ollé, A., Sala, R. 1999. Análisis microscópico de los instrumentos de Galería (Sierra de Atapuerca). Actividades desarrolladas y formas de uso. In Carbonell Roura E., Rosa Gonzáles A., Fernández-Lomana J.C.D. (eds.), *Atapuerca: ocupaciones humanas y paleoecología del yacimiento de Galería*, *Arqueología en Castilla y León 7*: 353-368.

Silvestrini, M., Bassetti, M., Boscato, P., Coltorti, M., Esu, D., Lemorini, C., Magnati, M., Peresani, M., Rossetti, P., Pinocchi, G., Tedesco, P. in press. An Acheulean site of the last Interglacial at Boccabianca (Cupra Marittima, Marche Region, Italy), *Rivista di Scienze Preistoriche*.

Transitions in human evolution and faunal changes during the Pleistocene in Latium (Central Italy)

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SUMMARY: The analysis of human evolution should not leave aside the evaluation of faunal and paleoenvironmental changes. As far as the evolution of the genus *Homo* is concerned, it seems at present that at least three major evolutionary transitions occurred in Europe during the time span between the late Early Pleistocene and Late Pleistocene. Looking at the Italian peninsula, Latium is a region of utmost interest to test hypotheses about these transitions. It includes in fact many bearing-hominid sites, from some among the earliest evidence of human settlements in Europe until the evolution of the Neandertals and the advent of early modern humans. Consolidate knowledge about the fossil evidence dealing with micro and macro vertebrates, bio-chronological mammal faunas sequences, and major faunal changes in Latium appears from the present analysis rather consistent with predictions about human evolution. Particularly, one of the most important faunal renewals took place in correspondence of the Early/Middle Pleistocene boundary, in the same time range when a transition from the human morph represented by the archaic cranium from Ceprano (ca. 800 ka) and Middle Pleistocene Europeans, presently referred to the species *Homo heidelbergensis*, is observed. By contrast, the transition in the Late Pleistocene between Neandertals and modern humans is not paralleled by any sharp faunal change. This occurrence supports scenarios where the emergence (in Africa) and subsequent world-wide diffusion of modern humans is seen as an exceptional event in the natural history of our species; it probably conditioned the faunal composition instead of being conditioned by large mammals paleobiogeographic trajectories.

1. INTRODUCTION

Latium is a region along the Tyrrhenian coast of central Italy of utmost interest to test hypotheses concerning human evolution during the Pleistocene and, particularly, in correspondence to crucial stages of transition between different species (and/or subspecies) of the genus *Homo*. As a matter of fact, our present knowledge about human evolution in the entire Italian peninsula find in Latium great part of the pertinent fossil record (Fig. 1). At the same time, the biochronological setting recently proposed for the Italian Middle Pleistocene large mammal faunas is based on faunal units (FU) that are represented in Latium by many key-sites (Gliozzi *et al.* 1997; Sardella *et al.* 1998).

The scenario of human evolution in Europe overcome the chronological limit posed by the advocates of the so-called "short chronology

(Roebrok & van Kolfschoten 1995) and suggest that hominids where present on the continent from about 1 million years or more (e.g., Peretto 2001; but compare Villa 2001). Hominids associated with archaic Paleolithic (Mode 1) are only represented so far in two sites, respectively in Italy (Ascenzi *et al.* 1996; Manzi *et al.* 2001) and Spain (Carbonell *et al.* 1999), both referred to about 800 ka (thousand years BP). A more abundant fossil record parallels the diffusion in Europe of Mode 2, or Acheulean, assemblages, largely represented after about 600 ka. It is commonly shared the conclusion that these human populations, referred to as *Homo heidelbergensis*, are the direct ancestors of the Neandertals, whose morphology clearly emerge only at the end of the Middle Pleistocene. Würmian Neandertals, included in the species *Homo neanderthalensis*, are recognised in several sites across Europe and the Near East. These late archaic humans – with the associated Mode 3, or Mousterian, artifacts – are the best known non-modern representatives of the genus *Homo* (cf. e.g. Trinkaus & Shipman 1993) and probably became extinct with the arrival in Europe of anatomically modern populations bringing Mode 4 cultures. It is presently largely recognised that these early modern Europeans, in turn, ultimately spread from Africa after 200-150 ka according to a model of “recent African origin” of *Homo sapiens* (e.g., Stringer & Andrews 1988; Aiello 1993; Krings *et al.* 1997).

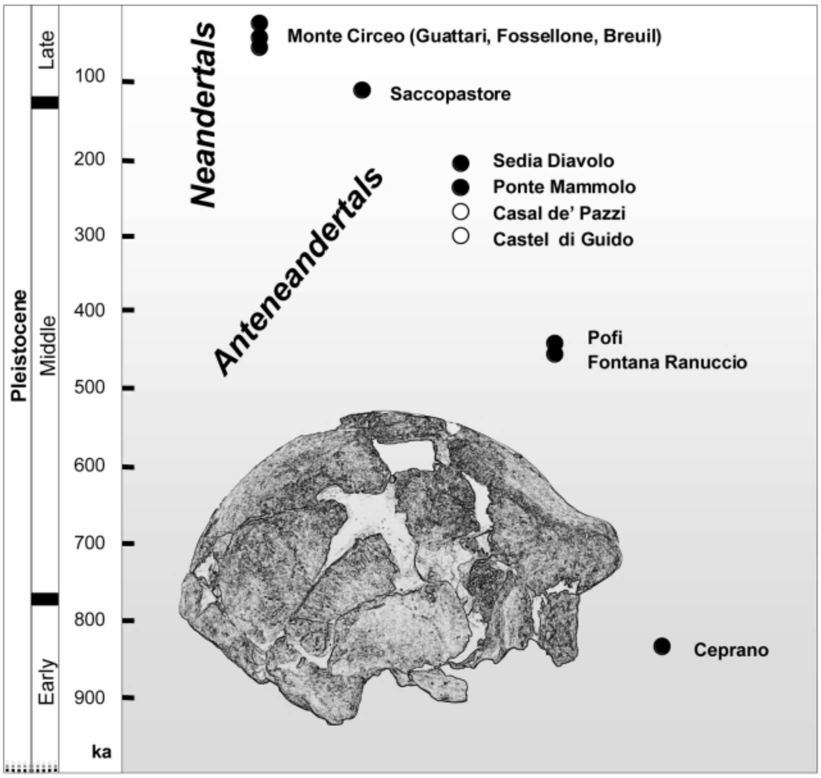

Fig.1 - Chronological inventory of sites in Latium with fossil human remains before the emergence of *Homo sapiens*; filled circles indicate discoveries due to the activity of the Italian Institute of Human Paleontology; "ka" is for thousands years before present. A drawing in right lateral view of the archaic cranium from Ceprano is also reported.

2. LATEST EARLY - EARLY MIDDLE PLEISTOCENE

The most ancient human remain found so far in Italy is the calvaria from Ceprano, in Southern Latium, a specimen that probably antedates the Early/Middle Pleistocene boundary, according to geo-chronological correlations at a regional scale supported by a series of K/Ar datings (Ascenzi *et al.* 1996, 2000; Ascenzi & Segre 2000). According to the phylogenetic interpretation recently given by Manzi *et al.* (2001), Ceprano may be considered as a good candidate to represent the last common ancestor of European and African Middle Pleistocene humans, ultimately between *Homo neanderthalensis* and (anatomically modern) *Homo sapiens*. The most relevant features of this important fossil specimen include the "*erectus*-like" general shape of the cranial vault, as well as a series of more localised traits that exhibit a very peculiar pattern and confer to the hominid from Ceprano the role of morphological link between more archaic (*Homo ergaster/erectus*) and more derived (*Homo heidelbergensis /rhodesiensis*) phenotypes.

In Latium, mammal faunas in close relationship with this important human remain are not clearly documented at present. However, the Redicicoli local fauna (Rome), including some Villafranchian species side by side with more advanced taxa – as *Stephanorhinus hundsheimensis*, megacerini and a bison closely related to *Bison schoetensacki* – seems to be older, while the faunal complex of Ponte Galeria FU (*sensu* Petronio & Sardella 1998) is younger. The latter is characterised by the arrival of immigrant species from Asia or central Europe (*Hyaena prisca, Mammuthus trogontherii, "Megaloceros" savini, Cervus elaphus acoronatus, Bos galerianus*), by the local evolution of pre-existing typical Villafranchian taxa (*Pseudodama* sp.), and by long-lasting latest Villafranchian-Galerian taxa (*Stephanorhinus hundsheimensis, Equus altidens, Hippopotamus* ex gr. *H. antiquus, "Megaceroides" verticornis*). Among elephants, the persistence of *Mammuthus meridionalis* cannot be ruled out, whereas the occurrence of *Elephas antiquus* has still to be proved. Scanty remains coming from the uppermost levels of Ponte Galeria Formation (*Hyaena prisca, Equus caballus, Bos primigenius*) possibly belong to the Isernia FU.

Therefore, the first occurrence of the genus *Homo* in Latium – and at present also in Europe, as far as skeletal remains are concerned and in association with the fossil samples found at Atapuerca TD6, Spain, referred to the new species *Homo antecessor* (Bermúdez de Castro *et al.* 1997) – seems to predate the transition from early to middle Galerian Mammal Ages (MAs), that took place after the post-Jaramillo strong climate worsening (OIS 24 and 22) and is referable to the early Middle Pleistocene (Gliozzi *et al.* 1997). Latium middle Galerian faunas, in fact, can be referred to three FUs – namely Ponte Galeria, Isernia, and Fontana Ranuccio – that have a fairly good stratigraphic and chronological control, ages around 750 ka (Milli 1998), 600 ka (Coltorti *et al.* 2000) and 450 ka (Biddittu *et al.* 1979) being respectively hypothesised. In the Fontana Ranuccio assemblage – the most representative of the homonymous FU – some typical Galerian taxa last occurred, while *Hippopotamus* ex gr. *H. amphibius* firstly appeared and the red deer is represented by the more advanced subspecies *C. e. eostephanoceros*. Thus, the faunal change that marks the transition to the following Aurelian MA has get under way.

Probably as younger as 300 Ka (or more) than the Ceprano hominid, there are sites with human remains in Italy which are referable to the core of the Middle Pleistocene (e.g., Manzi 2000, and references therein). Fontana Ranuccio (with four teeth, K/Ar dated to 458 ka) and possibly Pofi (with a fragment of cranial vault and two postcranial elements), are in southern Latium, along the valley of the river Sacco. According to the analyses published so far about the human remains recovered in these two sites (Passarello & Palmieri 1968; Ascenzi & Segre 1996), few or no Neandertal affinities have been encountered in the skeletal and dental elements, while features recalling those of Homo erectus have been reported for the central incisor found at Fontana Ranuccio.

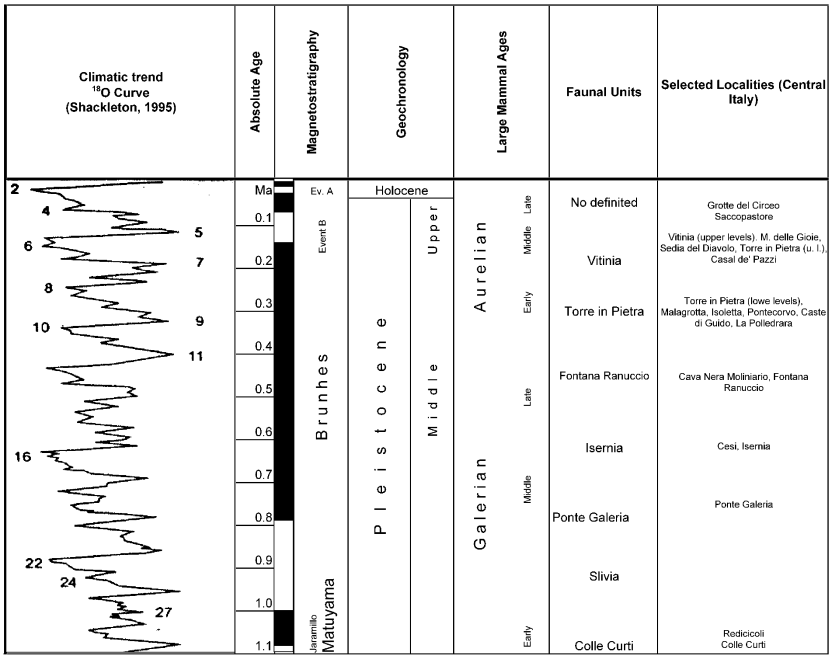

Fig.2 - Biochronological framework of Galerian and Aurelian mammal faunas of central Italy.

3. LATE MIDDLE PLEISTOCENE

During the late Middle Pleistocene, and particularly in the chronological range between approximately 350 and 150 ka, there are sites in Latium with fossil hominids commonly referred to as Anteneandertals, or *Homo heidelbergensis.* Among these sites, the most informative one is certainly Castel di Guido, near Rome, where fragmentary evidence of cranial and postcranial elements dated to about 300 ka was recovered (Mallegni *et al.* 1983; Mallegni & Radmilli 1988). Virtually all of the anatomical portions found at Castel di Guido are indicative of the trend which characterises human evolution in Europe during the Middle Pleistocene, that is the progressive appearance of Neandertal features. Such a "transitional" morphology toward more typical Neandertal phenotypes is represented by other specimens in Latium, actually in sites concentrated in the North-East outskirts of Rome (lower valley of the river Aniene). These are the Casal de' Pazzi archaic parietal (Manzi *et al.* 1990), which is referable to about 250-200 ka, as well as the penecontemporaneous femur and metatarsal from Sedia del Diavolo (Mallegni, 1986), and the femoral shaft from Ponte Mammolo (Biddittu *et al.* 1987).

Apparently, the morphological continuum observed in the evolution of human populations during the late Middle Pleistocene in Latium overlaps the transition in faunal assemblages, from previous FUs such as that from Fontana Ranuccio to the following Aurelian MA (Gliozzi *et al.* 1997). This took place around the climatic improvement which characterised the Mediterranean area starting from OIS 11 and followed until the beginning of the Late Pleistocene, given that latest Middle Pleistocene faunas are rather similar to OIS 5 complexes (early late Aurelian, *sensu* Gliozzi *et al.* 1997).

Two faunal complexes can be detected, namely Torre in Pietra and Vitinia FUs. In the Campagna Romana these faunas belong to two distinct sedimentary cycles: the "Aurelia Formation", related to OIS 9, and the "Vitinia Formation", related to OIS 7 (Conato *et al.* 1980; Caloi *et al.* 1998a). This late Middle Pleistocene mammal fauna (Torre in Pietra and Vitinia FUs), taken as a whole, shows relatively modern characters on account of the disappearance of the persistent Galerian taxa present in the Fontana Ranuccio FU (e.g. *Ursus deningeri*, stenonoid horses, megacerini) and the occurrences of *Ursus spelaeus*, *Canis lupus*, *Stephanorhinus hemitoechus*, a large horse with advanced morphology, *Megaloceros giganteus*, a red deer with a complete crown, and later (in the Vitinia FU) of *Dama dama tiberina*. At the beginning of climate worsening that will characterised the OIS 6, also *Equus hidruntinus* and a primitive *Mammuthus primigenius* appear in Latium. Mammal associations of this time range are modern in character and, generally, characterised by the abundance of *Elephas antiquus*, *Bos primigenius* and cervids. This should be consistent with the improvement of warm-temperate, quite wet climate during the positive oscillations and with the major extension of thermophilous forests and/or the absence of arid grasslands.

4. LATE PLEISTOCENE

Fossil human remains dated to the Late Pleistocene are scattered along the entire peninsula. As briefly recalled above, these include specimens referred to two distinct species, namely *Homo neanderthalensis* and *Homo sapiens*; the former being the result of the regional evolutionary continuum well documented by the European fossil record since – at least – 350 ka, whereas the latter probably derives from an allopatric event of speciation occurred in Africa at about 200-150 ka.

About Neandertals, the Italian fossil sample is mainly composed by fragmentary or largely incomplete specimens that, in general, are referable to a more stable characterisation than the previous late Middle Pleistocene fossil evidence. Until now, the sites where the most informative Neandertals can be found are, once more, in Latium and come from the well known sites of Saccopastore (Rome) and Grotta Guattari (Monte Circeo). The two Saccopastore crania (e.g. Sergi 1944, 1948) exhibit a clear Neandertal phenotype, including most of the derived traits which characterise this human group, although a number of plesiomorphic features are still present. From this perspective, their morphology is definitely consistent with their chronology, intermediate between those of the Anteneandertals of the Middle Pleistocene and the so-called "classic" Würmian Neandertals. According to the geochronology of the site proposed by Segre (1983), the two human specimens should be both referred to the OIS 5e; however, faunal remains from the same levels, compared with the Torre in Pietra sequence, better fit with the OIS 5c, suggesting a date around 100 ka (Caloi *et al.* 1998b).

Typically Neandertals are, some 50 thousand years later, the cranium and the two mandibles from Grotta Guattari. The detailed study carried out by Sergi (cf. Sergi 1974) and more recent reappraisals (e.g., various papers in Piperno & Scichilone 1991) agree in regarding the morphology of these specimens as a paradigmatic example of the pattern shared by all the European Neandertals of the OIS 4 and 3; with their long and broad braincase, the midfacial prognathism, the suite of more localised derived features (double-arched brow ridge, peculiar conformation of the occipital region, features of the petro-mastoid region, and so on). Monte Circeo is also a place where the late Neandertals can be found, and their possible bio-cultural relationships with modern human immigrants can be investigated (“acculturation”? see, e.g., Mellars 1992). Grotta Breuil, furnished in fact few specimens of Neandertal morphology associated to a Mousterian archaeological record at the young age of about 35 ka (various papers in Bietti & Manzi 1991; Manzi & Passarello 1995). After 30 ka or so, Neandertals can be considered extinct and modern humans are largely represented in Italy – in Latium, unfortunately, by very few and fragmentary specimens (recorded in sites such as Fossellone and, possibly, Farnesina) – by larger samples and sometimes by spectacular collections of entire skeletons, as those coming from the Gravettian and Epigravettian horizons in the chain of caves along the western coast of Liguria (e.g. Formicola 1991).

In the Late Pleistocene, particularly after the OIS 5, the renewal of faunas is almost completed. During late Aurelian, climatic events became more and more important; microclimatic and environmental conditions influenced the composition of mammal assemblages, which may be also strongly affected by anthropic influence. Among the large mammals, all extant species characterising the western Mediterranean area were present, while the Middle Pleistocene survivals – as large carnivores, pachyderms, and some cervids – progressively disappeared during latest Glacial stages (from OIS 4 to OIS 2), in association with the new occurrence of some species, more adapted to temperate/cold climatic conditions. However, according to the relatively temperate climate of the peninsula during the major glacial worsening, typical "cold" taxa are only sporadically recorded.

5. A TENTATIVE CONCLUSION

From this brief overview, it is apparent that in Latium – according also to the general pattern observed in Europe – at least three major transitions are documented by the human fossil record included between the late Early Pleistocene and the Late Pleistocene. Approximately, these transitional phases took place respectively at the beginning of the Middle Pleistocene, during the late Middle Pleistocene, and in a limited period (probably no longer than 10 thousand years) of the Late Pleistocene, close to the boundary between OIS 3 and 2 .

We have seen in a certain detail how the consolidate knowledge on major mammal faunal changes can help in testing these predictions about human evolution. Particularly, the important paleoclimatic and paleoenvironmental variations characterising the transition from the Early Pleistocene to the early Middle Pleistocene (from early Galerian to middle Galerian MAs), favoured a considerable faunal renewal in the same time span in which we observe the transition between hominids represented by Ceprano (ca. 800 ka) and Middle Pleistocene human populations referred to as *Homo heidelbergensis* (after about 600 ka), in possible association with the arrival in Europe of Acheulean immigrants (i.e., allochthonous populations bringing into Europe the Acheulean complexes).

Conversely, the passage from Galerian to Aurelian MAs does not seem to correspond to any sharp event in human evolution, but it has to be observed that while humans express features that will be subsequently fixed in the Neandertal variability, changes among large mammal assemblages appears similarly gradual, paralleling the increase of warm-temperate and relatively wet climates. Eventually, in the Late Pleistocene, the replacement by *Homo sapiens* of the latest archaic humans (the Neandertals) does not seem related to any particular change in the associated mammal faunas, but for the moderate increase of species adapted to colder conditions. This occurrence supports scenarios where the emergence (in Africa) and subsequent world-wide diffusion of modern humans is seen as an exceptional event in the natural history of our species, and that it probably conditioned the faunal composition instead of being conditioned by large mammals paleobiogeographic trajectories.

6. REFERENCES

Aiello, L.C. 1993. The fossil evidence for modern human origins in Africa: a revised view. *Am. Anthropol.* 95: 73-96.

Ascenzi, A. & Segre, A.G. 1996. Artefacts and human teeth at the Fontana Ranuccio Middle Pleistocene site (central Italy). *Anthropologie* XXXIV/1-2: 39-46.

Ascenzi, A. & Segre, A.G. 2000. The fossil calvaria of Homo erectus from Ceprano (central Italy): a new reconstruction. M. Aloisi, B. Battaglia, E. Carafoli & G.A. Danieli (eds.), In *The Origin of Humankind*: 25-33. Amsterdam: IOS.

Ascenzi, A., Biddittu, I., Cassoli, P.F., Segre, A.G. & Segre Naldini, E. 1996. A calvarium of late Homo erectus from Ceprano, Italy. *J. Human Evol.* 31: 409-423.

Ascenzi, A., Mallegni, F., Manzi, G., Segre, A.G. & Segre-Naldini, E. 2000. A reappraisal of Ceprano calvaria affinities with Homo erectus, after the new reconstruction. *J. Human Evol.* 39: 443-450.

Bermúdez de Castro, J.M., Arsuaga, J.L., Carbonell, E., Rosas, A., Martinez, I. & Mosquera, M. 1997. A hominid from the Lower Pleistocene of Atapuerca, Spain: possible ancestor to Neandertals and modern humans. *Science*, 276: 1392-1395.

Bietti, A. & Manzi, G. (eds) 1991. The Fossil Man of Monte Circeo. Fifty years of studies on the Neandertals in Latium. *Quaternaria Nova* I (1990-91): 9-678.

Biddittu, I., Cassoli, P.F., Radicati di Brozolo, F., Segre, A.G., Segre-Naldini, E. & Villa, I. 1979. Anagni a K/Ar dated Lower Middle Pleistocene site, Central Italy: preliminary report. *Quaternaria* 21: 53-71.

Biddittu, I, Mallegni, F. & Segre, A.G. 1987. Riss age human remain recovered from Pleistocene deposits in Ponte Mammolo (Rome, Italy). *Z. Morphol. Anthropol.* 77: 181-191.

Caloi, L., Palombo, M.R., Zarlenga, F. 1998a. Late Middle Pleistocene mammal faunas of Latium (Central Italy): Stratigraphy and Environment. *Quaternary International* 47-48: 77-86.

Caloi, L., Manzi, G. & Palombo, M.R. 1998b. Saccopastore, a stage-5-site within the city of Rome. In *SEQS Symposium (INQUA-SEQS'98), "The Eemian – Local sequeces, global perspectives" (Kerkrade, The Netherlands, September 1998), abstracts*.

Carbonell, E., Bermúdez de Castro, J. & Aesuaga, J.L. (eds.) 1999. Gran Dolina Site: TD6 Aurora Stratum (Burgos, Spain). *J. Human Evol.*, 37: 309-700.

Coltorti, M., Ton-That, T., Marzoli, A., Arzarello, M., Buoso, N., Corrado, S., Di Buscci, D., Minelli, A., Naso, G., Peretto, C., Thun Hohenstein, U., Villa, I. 2000. New Chronostratigraphic and Paleoclimatic Data from the "Isernia La Pineta" site, Molise, Italy. In *SubCommission on European Quaternary Stratigraphy (SEQS), 2000 Meeting The Plio-Pleistocene Boundary and the Lower/Middle Pleistocene transition. Type Areas and Sections: Abstracts*.

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

Formicola, F. 1991. Le sepolture paleolitiche dei Balzi Rossi. *Le Scienze* 280: 76-85.

Gliozzi, E., Abbazzi, L., Aambrosetti, P., 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, Ostracods from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art. *Riv. It. Paleont. Stratigr.*, 103 (3): 369-388.

Krings, M., Stone, A., Schimtz, R.W., Krainitzki, H., Stoneking, M. & Pääbo, S. 1997. Neandertal DNA sequences and the origin of modern humans. *Cell*, 90: 19-30.

Mallegni, F. 1986. Les restes humaines du gisment de Sedia del Diavolo (Rome) remontant au Riss final. *L'Anthropologie* 90: 539-553.

Mallegni, F. & Radmilli, A.M. 1988. Human temporal bone from the lower Paleolithic site of Castel di Guido near Rome. *Am. J. Phys. Anthropol.* 76: 175-182.

Mallegni, F., Marani-Costantini, R., Fornaciari, G., Longo, E.T., Giacobini, G. & Radmilli, A.M. 1983. New European fossil hominid material from an Acheulean site near Rome (Castel di Guido). *Am. J. Phys. Anthropol.* 62: 263-274.

Manzi, G. 2000. Fossil Italians. What we know and what we could learn about human evolution from the Italian fossil record. In M. Aloisi, B. Battaglia, E. Carafoli & G.A. Danieli (eds.), *The Origin of Humankind*: 51-67. Amsterdam: IOS (IVSLA Series).

Manzi, G. & Passarello, P. 1995. At the archaic/modern boundary of the genus Homo: the Neandertals from Grotta Breuil. *Current Anthropol.*, 36: 355-366.

Manzi, G., Salvadei, L. & Passarello, P. 1990. The Casal de' Pazzi archaic parietal: comparative analysis of a new fossil evidence from the late Middle Pleistocene of Rome. *J. Human Evol.* 19: 751-759.

Manzi, G., Mallegni, F. & Ascenzi, A. 2001. A cranium for the earliest Europeans. Phylogenetic position of the hominid from Ceprano. Italy. *Proc. Natl. Acad. Sci.* USA (in press).

Mellars, P.A. 1992. Archaeology and the population-dispersal hypothesis of modern human origins in Europe. *Philos. Trans. R. Soc.* 337(1280): 225-234.

Milli, S. 1998. Depositional setting and high-frequency sequence stratigraphy of the middle-upper Pleistocene to Holocene deposits of Roman Basin. *Geologica Romana* 33 (1977): 99-136

Palombo, M.R., in press, Herbivore guils from the Middle Pliocene to the Middle Pleistocene in Italy. *Le Quaternaire*.

Passarello, P. & Palmieri, A. 1968. Studio sui resti umani di tibia e di ulna provenienti da strati pleistocenici della cava Pompi di Pofi (Frosinone). *Riv. di Antropol.* LV: 139-162.

Peretto, C. 2001. The oldest human population in Europe: 'long' and 'short' chronologies. In P.V. Tobias, M.A. Raath, J. Moggi-Cecchi & G.A. Doyle (eds.), *Humanity from African Naissance to Coming Millenia*: 175-180. Firenze-Johannesburg: Firenze University Press-Witwatersrand University Press.

Piperno, M. & Scichilone, G. (eds) 1991. *The Circeo 1 Neandertal Skull. Studies and Documentation*. Roma: Istituto Poligrafico e Zecca dello Stato.

Roebrok, W. & Van Kolfschoten, T. 1995. The eraliest occupation of Europe: a reappraisal of artefactual and chronological evidence. *Analecta Praehist. Leidensia* 27: 297-315.

Segre, A.G. 1983. Geologia quaternaria e Paleolitico nella bassa valle dell'Aniene. In L'Uomo di Saccopastore e il suo Ambiente - I Neandertaliani nel Lazio. *Riv. di Antropol.*, suppl. vol. LXII: 87-98.

Sergi, S. 1944. Craniometria e craniografia del primo paleantropo di Saccopastore. *Ricerche di Morfologia* 20-21: 733-791.

Sergi, S. 1948. Il cranio del secondo Paleantropo di Saccopastore. *Palaeontographia Italica* XLII (1942-46): 25-164.

Sergi, S., 1974, *Il cranio neandertaliano del Monte Circeo (Circeo I)*. Roma: Accademia Nazionale dei Lincei.

Stringer, C.B. & Andrews, P. 1988. Genetic and fossil evidence for the origin of modern humans. *Science* 239: 1263-1268.

Trinkaus, E. & Shipman, P. 1993. *The Neandertals. Changing the Image of Mankind*. New York: A.A. Knopf.

Villa, P. 2001. Early Italy and the colonization of Western Europe. *Quaternary International* 75: 113-130.

Human/carnivore interaction in the Middle Pleistocene of Latium (Central Italy): an open question

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SUMMARY: Current views on the earliest peopling of Europe, and on interaction between carnivore and primitive hominids, are tested against the complex palaeontological and archaeological record of Latium. While the available evidence does not allow for a full evaluation of late Pliocene or early Pleistocene peopling, there is ample evidence of human colonisation of the area after 500 ka. During the middle Pleistocene, human groups successfully competed in Latium with modern carnivores, possibly occupying a niche that only partially overlapped with that of other predators.

1. Current Views on the Earliest Peopling of Europe

The chronology of the first colonisation of Europe by hominids is still a hotly debated question. In the last fifty years or so, "long chronologies" of 1 to 2 Ma have been again and again opposed to "short chronologies" of approximately 500 ka. In recent years a compromise of a kind was reached by Dennel & Roebroeks (1996), whose "revised short chronology" suggests an intermittent peopling of the Mediterranean perimeter of Europe around 1 Ma, and a stable colonisation starting around 600 to 500 ka. An even greater antiquity is actually claimed for some European sites, but the dates are still controversial (see Palmqvist & Arribas 2001; Peretto 2001 for an update of the debate).

Whatever the exact date of the earliest peopling, given the very limited technological complexity at the time, any dispersal of human groups out of Africa and into the middle latitudes of Eurasia is better seen in the context of similar events involving other species: human behaviour, including the expansion into new environments, underwent the same processes as other large mammals. Humans, furthermore, were both adapted to meat consumption (Henneberg *et al.* 1998) and in need of eating it, at least seasonally, in order to colonise areas in which vegetation growth was limited for several months (Mussi 1999). Accordingly, human/carnivore interaction at the Plio-Pleistocene boundary must be investigated, and the available resources evaluated.

After Palmqvist *et al.* the sabre-tooth felid *Megantereon* played a significant role in Late Villafranchian Eurasia, as this hypercarnivore supposedly produced large numbers of carcasses. Furthermore, the dental characteristics of Machairodontinae, and most notably the peculiar development of both the enlarged upper incisors and the upper carnassials, would not have allowed for carcasses to be fully stripped of their flesh. Subsequently *Megantereon* activity would have opened a niche for scavengers, including both *Homo* and *Pachycrocuta,* allowing for late Pliocene human colonisation of Europe. (Palmqvist & Arribas 2001; Palmqvist *et al.* 1996; Martínez-Navarro & Palmqvist 1996).

P. brevirostris was a large, short-faced hyena, well adapted to the destruction of carcasses and bone consumption, as implied by its short distal limb segments which gave it greater power and more stability for dismembering and carrying (Palmqvist *et al.* 1996b; Arribas & Palmqvist 1998; Turner & Antón 1996). Turner (1990, 1992, 1994), accordingly, had previously argued that humans could not have easily won the competition with this large hyena for access to *Megantereon* leftovers, making it difficult for hominids to develop an adaptive scavenging pattern. Consequently, a stable, suitable and productive niche for hominids only opened in Europe around 500 ka, when sabre-toothed felids and giant hyenas were replaced by modern African carnivores such as the lion, the leopard and the spotted hyena.

Meanwhile, new evidence on human behaviour came to light on two archaeological sites: the zooarchaeological analysis of the so-called “Aurora Stratum” of Atapuerca, pointed to primary and early access to carcasses possibly as early as 1 Ma ago (Diéz *et al.* 1999); while at the 400-450 ka year old site of Schöningen, in northern Germany, exceptional local conditions allowed for the preservation of sophisticated wooden spears, associated with the remains of butchered horses (Thieme 1997), giving positive evidence of hunting capacities.

2. The Italian record

As far as Italy is concerned, there is little doubt that human settlement was well underway during the early Middle Pleistocene, possibly some time before 600 ka after the recent dates of Notarchirico and Isernia (Coltorti *et al.* 2000: Piperno 1999). An earlier age has also been suggested on a few more sites (for a discussion: Mussi 1995; Mussi in press; Villa 2001; see also Palombo *et al.* 2001).

Overall, the Middle Pleistocene was a time of substantial faunal turnover, occurring in Italy during the worsening climate which followed the Early/Middle Pleistocene boundary, correlated with OIS 25 by Cita & Castradori (1994) (Palombo & Mussi 2001 and references there in). The main climatic fluctuations of the Pleistocene affected physical and/or biotic environmental variations and are possibly reflected in concurrent bioevents in multiple lineages. There are changes in the richness and diversity of the fauna and flora, and the structure of mammal communities is sometimes affected. Different lines of analysis actually suggest an increase in the richness and diversity of large mammals. They point, most notably, to great numbers of both medium and large herbivores of open environments, including pachyderms, and to a progressively changing carnivore guild.

The final Lower Pleistocene (Early Galerian, Colle Curti FU, *sensu* Gliozzi *et al.* 1997) carnivore guild is dominated by large, flesh eating and bone consuming species (Tab. 1).

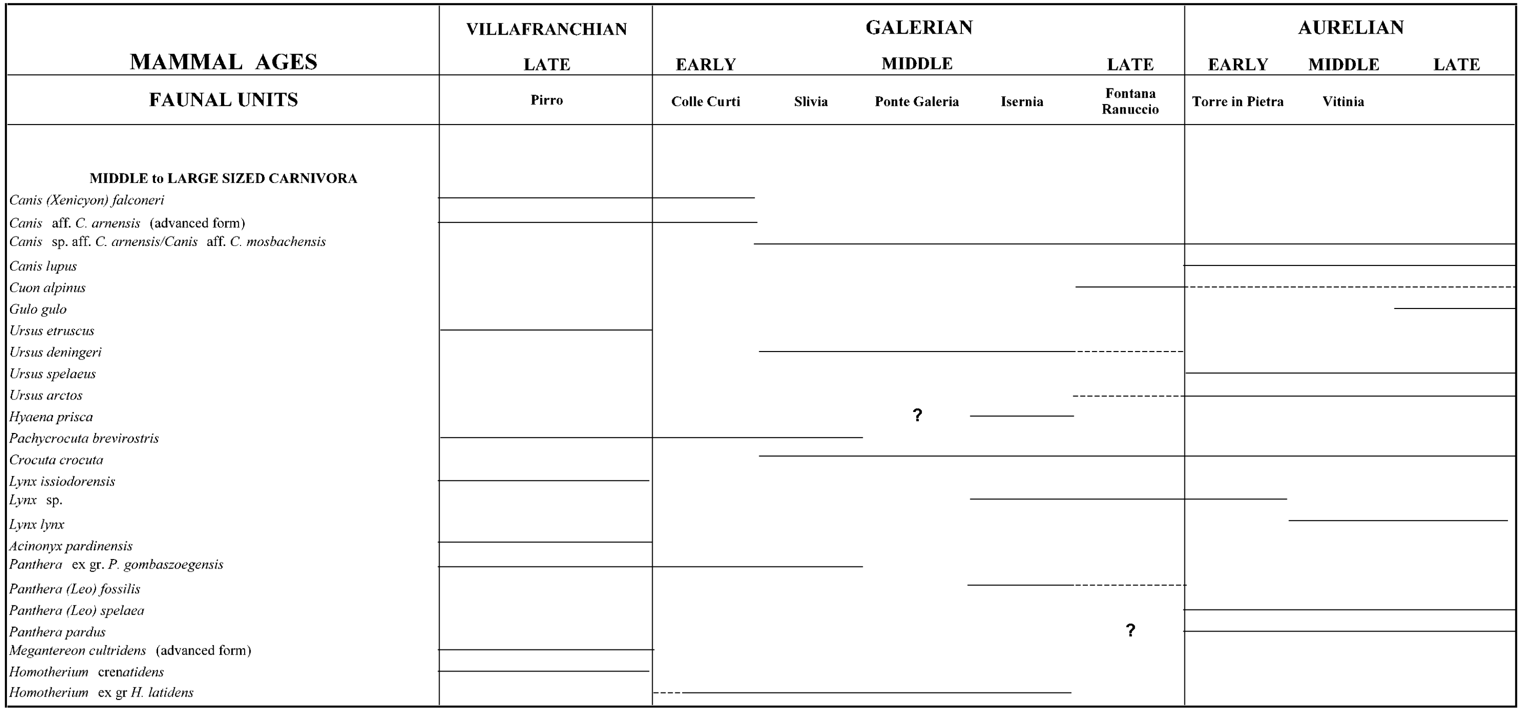
Canis etruscus, with a cranial morphology similar to that of modern omnivorous species, disappears in the late Villafranchian, before the Pirro FU. The same happens to *Canis (Xenocyon) falconeri* in the early Galerian. This very large canid has a craniodental morphology similar to that shown by extant hypercarnivorous canids, more than 70% of whose diet includes vertebrate meat. According to morphofunctional skeletal features, the species may have developed a cooperative behaviour similar to that of modern African wild dogs, who are savannah hunters also active by day (Palmquist *et al.* 1999).

More large carnivores become extinct in the Late Villafranchian, including *Megantereon ”cultridens”*[1] and the large cheetah *Acinonyx pardinensis* (even if a small *Acinonyx* possibly survives until later in Mediterranean environments: Moullé 1997). Throughout the Galerian, however, another sabre-tooth cat is active: this is *Homotherium latidens*, possibly living in small prides, adapted to pursuit hunting and able to attack large prey, such as young elephants. Accordingly, it was also producing carcasses rich in flesh.

Pachycrocuta brevirostris, the large and effective carcass destroyer, disappears later than other species, and is still well represented for part of the middle Galerian.

More large carnivores enter the Italian scene during the Galerian. *Panthera (Leo) fossilis*,

Tab.1 - Biochronology of selected medium-large carnivores of the Italian peninsula, dating from the latest Early Pleistocene to the Latest Pleistocene.



Tab.2 – Local large mammal faunas from selected Italian localities from the latest Early Pleistocene (latest Villafranchian) to the Middle Pleistocene (middle Aurelian).
(1) references in Palombo *et al.* (in press), (2) references in Mussi (2001).

MAMMAL AGE	GALERIAN									AURELIAN																
	EARLY		MIDDLE				LATE			EARLY						MIDDLE										
FAUNAL UNIT	C.Curti		P. G.	Isernia			Fontana Ranuccio			Torre in Pietra						Vitinia										
Selected Taxa / Selected Localities	Colle Curti (1)	Redicicoli (1)	Ponte Galeria (various sites) (1)	Isernia-La Pineta (1)	Cesi (1)	G.R.A. (Roma) (1)	Fontana Ranuccio (1)	Cava Pompi (2)	Cava nera Molinario (1)	La Polledrara di Cecanibbio (1)	Torre in Pietra (lower) (1)	Castel di Guido (1)	Malagrotta (1)	Pontecorvo (1)	Pignataro	Bucine (1)	Campo Verde (1)	Torre in Pietra (upper) (1)	Vitinia (upper beds) (1)	Cerveteri (1)	Casal de' Pazzi (1)	Sedia del Diavolo (1)	Monte delle Gioie (1)	Prati Fiscali (1)	Carnello (2)	Valle Radice (2)
Human impact	-	-	-	X	-	-	X	X	-	X	X	X	X	X	X	X	X	X	X	-	X	X	X	-	X	X
Macaca sylvanus	-	-	-	-	-	-	?	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
Hyaenidae gen. spec. indet.	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crocuta crocuta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	X	-	-	-	X	X
Canis (Xenocyon) ex gr. *C. falconerii*	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canis sp. aff. *C. arnenesis*	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	?	-	-	-	-	-
Canis sp. aff. *C."mosbachensis"*	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canis lupus	-	-	-	-	-	-	-	-	-	X	X	X	cf.	-	-	X	-	X	X	-	X	X	-	-	-	-
Cuon alpinus	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ursus spelaeus	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Ursus deningeri	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ursus arctos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Ursus sp.	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-
Homotherium ex gr. *H. latidens*	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lynx sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Panthera (Leo) fossilis	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panthera (Leo) spelaea	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X	X
Panthera (Leo) sp.	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Panthera pardus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	X	X
Elephantinae gen. Spec. Indet.	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mammuthus meridionalis	X	X	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mammuthus trogontherii	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. ex gr. *M. chosaricus-M. primigenius*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-
Equus altidens	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equus suessenbornensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	aff.	-	-	-	-	-	-	-	-	-	-
Equus hydruntinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-
Equus ferus	-	-	?	-	cf.	-	X	-	-	X	X	X	X	X	-	-	X	X	-	X	X	X	-	X	X	-
Stephanorhinus sp.	-	-	-	-	-	-	-	-	-	X	-	-	-	X	X	X	X	-	X	X	X	-	-	-	X	X
Stephanorhinus hundsheimensis	-	X	X	X	X	-	cf.	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. sp. aff. *S. hundsheimensis*	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	cf.	-	-	-	-	-	-	-	-	-
Stephanorhinus hemitoechus	-	-	-	-	-	-	-	-	-	-	X	-	cf.	-	-	-	cf.	X	-	-	-	X	X	X	-	-
Sus scrofa	-	-	-	X	-	-	X	-	-	-	X	-	X	?	-	X	X	X	-	-	X	X	-	-	-	-
Hippopotamus ex gr. *H. antiquus*	X	X	X	X	cf.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippopotamus ex gr. *H. amphibius*	-	-	-	-	-	-	X	-	X	-	-	X	X	X	X	-	X	X	-	-	X	X	X	-	-	-
Capreolus capreolus	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	X	X	X	-	-	X	-	-	-	-	-
Pseudodama sp	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dama clactoniana	-	-	-	X	X	cf.	X	-	-	-	-	-	cf.	-	-	-	-	-	-	?	-	X	-	-	-	-
Dama dama	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X	X	-	-
Dama sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Cervus elaphus	-	-	X	X	X	-	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Megaceroides verticornis	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaceroides solhilacus	-	-	-	X	X	-	-	cf.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaloceros savini	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megaloceros giganteus	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	cf.	X	-	-	-	-	-	-	-	-	-
Megacerini indet.	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bos galerianus	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bos primigenius	-	-	?	-	-	X	X	X	-	X	X	X	X	-	X	?	X	X	X	X	X	X	X	X	-	-
Bison sp. cf *B. (Eobison) degiuli*	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bison sp. aff. *B. schoetensacki*	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bison schoetensacki	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bison priscus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-
Hemitragus bonali	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caprinae gen. Spec. Indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Capra ibex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X

the primitive lion, markedly larger than modern lions, disperses into the Old World at about 600 ka, when open savannah or steppe-like environments develop. It is then substituted during the late Middle Pleistocene by the more advanced cave lion, *Panthera (Leo) spelaea*. Both taxa, just like modern lions, were most probably able to hunt large prey, often in groups. Other carnivores (including humans) were not allowed to gain access to the carcasses, and lions could displace other predators in order to scavenge (Ewer 1998).

Crocuta crocuta, the spotted hyena, is another open environment group hunter, and a marginal scavenger as well. It is also present in Italy at the beginning of the Middle Pleistocene (middle Galerian, Slivia FU, *sensu* Gliozzi *et al.* 1997). There is no further evidence of the spotted hyena in the late Galerian and lower Aurelian, but then there are more and more occurrences during the middle and late Aurelian. *Hyaena prisca*, of possibly similar habits, is only documented at G.R.A., a site on the outskirts of Rome. *Ursus deningeri*, the brown bear, whose hunting aptitude is well documented in modern populations (Ewing 1998), is similarly first documented in middle Galerian assemblages.

3. The Case of Middle Pleistocene Latium

Many archaeological and palaeontological sites have been discovered in the area surrounding Rome, the *Campagna Romana*, and more are located in the rest of Latium. In the discussion below, we will focus on the evidence from Latium itself, but the 26 assemblages of our sample also include a few sites, such as Isernia, outside the regional border, even if not far away from it (Tab. 2). The latitude ranges between 41° and 43° N.

The earliest part of the record is not that rich, however. Early and middle Galerian faunas were discovered at Redicicoli and Ponte Galeria, both in the Campagna Romana (Colle Curti and Ponte Galeria FUs[2]). The remains are not abundant, and carnivores, most notably, are probably under represented. There is no evidence, so far, of any human presence. Middle Galerian faunas are even scarcer and one must turn to Isernia as a reference site, with the earliest evidence of the dispersal in Italy of the lion as well as *Ursus deningeri*.

This large-bodied brown bear is first documented in Latium at Fontana Ranuccio (Fontana Ranuccio FU).

At this site, which K/Ar dating puts at c. 450 ka old, the much more diversified mammal assemblage also includes *Cuon alpinus*, while very large cervid species are reduced in number (Tab. 2). There is also ample evidence of human presence, such as some teeth, and Acheulean assemblages with both lithic and bone handaxes. More archaeological evidence turned up on sites of the same age, such as Cava Pompi and Valchetta Cartoni, which are less endowed with faunal remains.

There is no reason why the Latium inhabitants of the time should have been less skilled hunters than the “contemporary” ones of Schöningen, who killed horses with sophisticated wooden spears. If this hypothesis is correct, then they would have been competing for the same class of prey as lions and brown bears.

Outstanding palaeontological evidence from the Campagna Romana only comes later, when a combination of Late Quaternary volcanism and exogenous agents led to widespread site preservation and to a good chance of archaeological recovery (Arnoldus-Huyzendveld *et al.* 2001; Caputo *et al.* 2001). This is better seen on the many archaeological sites of the Aurelian Formation as well as on those of the subsequent Vitinian Formation (Tab. 2). With the end of Galerian and the transition to the Torre in Pietra FU there is evidence of a significant change as the fauna progressively acquires a modern character. The relevant sites, namely those of the Aurelian Formation, are dated to OIS 9, but the renewal might have started earlier, around the OIS 11/OIS 10 transition, when in the Mediterranean area the interstadial climate had become progressively milder and the average rate of humidity had increased (Vergnoux-Grazzini *et al.* 1990). Most of the large Galerian herbivores, such as *Equus altidens*, megacerini and *Bison schoetensacki* become extinct, while new carnivores appear. These are small species, however, except for the medium sized *Canis lupus*. The pachyderms decline. Overall, during the Aurelian, the percentage of medium to large carnivores and herbivores becomes more balanced (Fig. 1).

A smaller number of large bodied animal species cannot have been detrimental to humans. Even more so, at a time of increased faunal richness and diversity, when new occurrences prevail over extinctions, as happens in the transition between Torre in Pietra and Vitinia FUs. The spectacular record from the Aurelian Formation sites, such as La Polledrara, possibly points to the fact that a more limited number of pachyderm species was amply compensated by the higher frequency of the extant taxa. If, as Anzidei *et al.* (1988) suggest, killing weak animals trapped in the mud and scavenging carcasses of dead animals were two possible options at spots where herds of elephants seasonally congregated, human group organisation would have been adequate to keep at bay, at least for a while, an array of powerful competitors, including both lone hunters, such as the brown bear, and group hunters, such as lions, spotted hyenas and wolves. Evidence of artificial bone modification (Anzidei & Cerilli 2001) is further evidence of some control over the carcasses.

4. FINAL REMARKS

The Italian record does not allow for fully testing the theory of Palmqvist *et al.* (1996, 1999) as to the relevance of sabre-tooth cats in the production of fleshy carcasses for human consumption. The scarcity of archaeological sites during the early Galerian, however, rather points in the opposite direction. The evidence from Latium rather conforms to Turner's anticipations (1992a; 1992b; 1994), in that there is good evidence of human peopling after 500 ka, when the fauna – including carnivores – acquires a modern character. The many sites of OIS 9 suggest that humans at the time, on top of a possible ability to kill medium sized herbivores, were also able to take advantage of

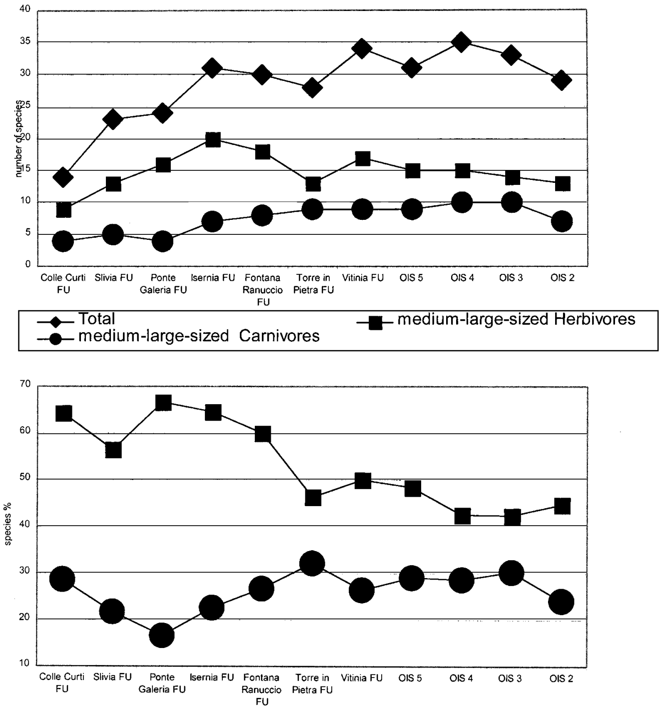


Fig.1 - Line chart of selected medium and large herbivores and carnivores.

pachyderms and other animals dying naturally. This means that they were also able to win in an aggressive confrontation with other carnivores similarly interested in carcasses.

This also points to the fact that, just like any other predator, they included meat in their diet in an opportunistic way, hunting, searching for dead animals, scavenging leftovers, maybe even displacing other carnivores and stealing their prey. A limited running capacity and moderate strength was supplemented by cultural means, such as the ability to shape weapons – possibly wooden ones – and to fully co-operate in the hunt. Language development can only be guessed at, but would have helped greatly in planning ambushes, while flying vultures and crows – all of them amply documented in middle Pleistocene inventories (M. Pavia 2001 - personal communication) would have made it easier to find carcasses.

Being omnivorous, however, and because of their strictly diurnal activity, humans differ from other predators. Overall, there are grounds to believe that this ecologically flexible and adaptable species took advantage of a niche only partially overlapping that of other carnivores.

5. REFERENCES

Anzidei, A.P., Angelelli, F., Caloi, L., Damiani, I., Pacciarelli, M., Palombo, M.R., Saltini, A.C., Segre, A.G. 1988. Il giacimento pleistocenico de "La Polledrara" di Cecanibbio (Roma), relazione preliminare. *Archeologia Laziale*, 9: 361-368.

Anzidei, A.P. & Cerilli, E. 2001. The faunas of La Polledrara di Cecanibbio and Rebibbia Casal de' Pazzi (Rome, Italy) as an indicator for site formation in a fluvial environment. *This volume.*

Arnoldus-Huyzendveld, A., Zarlenga, F., Gioia, P. & Palombo M.R. 2001. Distribution in space and time and analysis of preservation factors of the Pleistocene deposits. *This volume.*

Ascenzi, A., Biddittu, I., Cassoli, P.F., Segre, A.G. & Segre Naldini, E. 1996. A calvarium of late *Homo erectus* from Ceprano, Italy. *J. Human Evolution* 31: 409-423.

Cita, M.B. & Castradori, D. 1994. Workshop on marine sections from the Gulf of Taranto (Southern Italy) usable as potential stratotypes for the GSSP of the Lower, Middle and Upper Pleistocene: *Il Quaternario* 7 (2): 677-692.

Caputo, C;, Arnoldus-Huyzendveld, A. & Pugliese, F. 2001. Natural environment: geomorphological features and lithic resorce. *This volume*

Coltorti, M., Ton-That, T., Marzoli, A., Arzarello, M., Buoso, N., Corrado, S., Di Bucci, D., Minelli, A., Naso, G., Peretto, C., Thun Hohenstein, U., Villa, I. 2000. New Chronostratigraphic and Paleoclimatic Data from the "Isernia La Pineta" site, Molise, Italy. In *SubCommission on European Quaternary Stratigraphy (SEQS) 2000 Meeting The Plio-Pleistocene Boundary and the Lower/Middle Pleistocene transition: Type Areas and Sections: Abstracts*

Dennel, R.W., Roebroeks, W. 1996. The earliest colonisation of Europe: the short chronology revisited. *Antiquity* 70: 535-542.

Diéz, J.C., Fernádez-Jalvo, Y., Rosell, J., Cáceres, I. 1999, Zooarcheology and taphonomy of Aurora Stratum (Gran Dolina, Sierra de Atapuerca, Spain). *J. of Human Evolution* 37, 3-4, Special Issue: 623-652.

Echassoux, A. 2001. Etude paleontologique, taphonomique et archeozoologique des grands mammifères du Pléistocène inférieur de la grotte du Vallonet (Roquebrune-Cap-Martini, Alpes Maritimes, *Unpublished Doctoral Thesis*, Muséum National d'Histoire Naturelle, Paris.

Ewer, R.F. 1998. *The Carnivores*: 500pp. Ithaca, Cornell University Press.

Gliozzi, E., Abbazzi, L., Ambrosetti, P., 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, Ostracods from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art. *Riv. It. Paleont. Stratigr.* 103 (3): 369-388.

Henneberg, G., Sarafis, V., Mathers, K. 1998. Human adaptation to meat eating. *J. of Human Evolution* 13: 229-234.

Martínez-Navarro, B. & Palmqvist, P. 1995. Presence of the African machairodont *Megantereon whitei* (Broom 1937) (Felidae, Carnivora, Mammalia) in the Lower Pleistocene site of Venta Micena (Orce, Granada, Spain), with some considerations on the origin, evolution and dispersal of the genus. *Journal of Archaeological Science* 22: 569-582.

Martínez-Navarro, B. & Palmqvist , P. 1996. Presence of the African saber-toothed felid *Megantereon whitei* (Broom 1937) (Mammalia, Carnivora, Machairodontidae) in Apollonia-1 (Mygdonia basin, Macedonia, Greece). *Journal of Archaeological Science* 23, 869-872.

Moullé, P.E. 1997. Les grands mammifères du Pléistocène inférieur de la grotte du Vallonet (Roquebrune-Cap-Martini, Alpes Maritimes: Synthèse des études antérieurs et nouvelles déterminations. *Bulletin du. Musée d'Anthropologie Préhistorique de Monaco* 39.

Mussi, M. 1995. The Earliest Occupation of Europe: Italy. In Roebroeks, W. & Van Kolfschoten, T. (eds.), *The Earliest Occupation of Europe*: 27-50. Leiden: University of Leiden.

Mussi, M. 1999. The Neandertals in Italy: a tale of many caves. In Gamble, C. & Roebroeks, W. (eds.), *The Middle Palaeolithic Settlement of Europe*: 49-79. Leiden: University of Leiden.

Mussi, M. 2001. *Earliest Italy. An overview of the Italian Palaeolithic and Mesolithic*. New York: Plenum Publishing Company.

Palmqvist, P., Martínez-Navarro, B. & Arribas, A. 1996. Prey selection by terrestrial carnivores in a lower Pleistocene paleocommunity. *Paleobiology,* 22: 514-534.

Palmqvist, P., Martínez-Navarro, B. & Arribas, A. 1999. Ecomorphological study of large canids from the lower Pleistocene of southeastern Spain. *Lethaia*, Vol. 32: 75–88.

Palmqvist, P., Arribas, A. 2001. Chronology and ecology of the first human dispersal out of Africa, with a review of the archaeological and paleoanthropological evidence. *Paleontologia i Evolució* 32-33: 7-22.

Palombo, M.R., Azanza, B. & Alberdi, M.T. in press. Italian mammal biochronology from Latest Miocene to Middle Pleistocene: a multivariate approach. *Geologica Romana*.

Palombo M.R., Abbazzi, L. Agostini, S., Massa, P. & Mussi, M. 2001. Middle Pleistocene fauna and lithic implements from Pagliare di Sassa (L'Aquila, Central Italy). *This volume.*

Palombo, M.R., Mussi, M. 2001. Large Mammal Guilds and Human settlement in the Middle Pleistocene of Italy. *Boll. Soc. Paleont. It.* 40 (2): 11.

Peretto, C. 2001. The oldest human population in Europe: 'long' and 'short' chronologies. In P.V. Tobias, M.A. Raath, J. Moggi-Cecchi & G.A. Doyle (eds.), *Humanity from African Naissance to Coming Millenia*: 175-180. Firenze–Johannesburg: Firenze University Press-Witwatersrand University Press.

Piperno, M. 1999. *Notarchirico. Un sito del Pleistocene medio iniziale nel bacino di Venosa*: 621pp. Museo "L. Pigorini", Ed Osanna Venosa

Thieme, H. 1997. Lower Palaeolithic hunting spears from Germany. *Nature* 385: 807.

Turner, A. 1990. The evolution of the guild of larger terrestrial carnivores in the Plio-Pleistocene of Africa. *Geobios* 23: 349-368.

Turner, A. 1992a. Large carnivores and earliest European himinids: Changing determinants of resource availability during Lower and Middle Pleistocene. *J. Hum. Ev.* 22: 109-126.

Turner, A. 1992b. Villafranchian – Galerian larger carnivores of Europe: dispersion and extinctions. *Courier Forsch. Inst. Senckenberg* 153: 153-160.

Turner, A. 1994, Evolution and Dispersion of large Mammals in Europe During the Time Span of *Homo erectus*. *Courier Forsch.-Inst. Senckenberg* 171: 241-247.

Turner, A. & Antón, M. 1996. The giant hyena, Pachycrocuta brevirostris (Mammalia, Carnivora, Hyaenidae). *Geobios* 29: 455-468.

Villa, P. 2001, Early Italy and the coloniszation of Western Europe. *Quaternary International* 75: 113-130.

6. NOTES

[1] The taxon has been identified as *M. whitei* by Martínez-Navarro & Palmqvist (1995), in whose opinion in Western and Central Europe *M. cultridens* gave rise to *M. white*i at the Plio/Pleistocene boundary.

[2] For Slivia FU, an age older than the other middle Galerian FUs, is generally accepted on the basis of the occurrence of *Mimomys savini* and the survival of some Villafranchian carnivores (Gliozzi *et al.* 1997). We do not rule out, however, that both the Slivia and the Ponte Galeria assemblages actually belong to the same FU. In fact, the identification of most herbivores of the Slivia local fauna is doubtful, and not much is known of the carnivores and micromammals belonging to Ponte Galeria FU. Accordingly, the differences between the two faunas might well be overestimated.

The World of Elephants - International Congress, Rome 2001

Palaeontology and prehistory in Central Italy: an historical summary

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SUMMARY: Knowledge on prehistory and pleistocene palaentology from the 16th to the 20th centuries in Central Italy Latium is hereafter described. The first identification of middle palaeolithic flint tools of human origin took place around 1550. In the middle of the 17th century the first macromammals fossil bones were observed. Only on or about 1850 the scientific organization of palaentology and archaelogy started in Southern Latium beginning with the lower palaeolithic (Acheulean). A substantial number of research studies were realized after the end of the 19th century.

It is in the 16th century that the attention toward palaentology and prehistory, as critical evaluation of the concrete evidence concerning the past, increased and prevailed on the medieval beliefs. Michele Mercati, at the court of Pope Clemente VIII, clearly recognised the human origin of retouched flints (Mercati 1574) and, afterwards (1664), Virgilio Romano was exhibiting in his private museum in Rome a massive canine tooth of Hippopotamus major found in the Pleistocene gravels along the Via Nomentana - one of the main roads that run from Rome (toward the North East in this case) and cuts the old alluvial sediments of the lower valley of the river Aniene, tributary of the Tiber. In 1644, an erudite French voyager, de Mancony, noticed some bones of an ancient elephant from the foundations of the Vatican; in 1688, Giovanni Ciampini recognised and described bone of *Elephas antiquus* in Vitorchiano, in North-Western Latium. To this earlier stage of palaentological and prehistoric knowledge also contributed, during the 17th century, the activity concerning ancient Latium by the encyclopaedic Jesuit Atanasio Kircher (1665, 1671).

However, the more properly scientific beginning of the vertebrate palaentology and paleolithic archaelogy has to be attributed to the pioneers that in the first halfof the 19th century started systematic explorations and researches, that were developed in the so-called Campagna Romana (the country area around Rome) and, more in general, in Central Italy. Particularly we recall: G.B. Brocchi, for the first surveys on the Plio-Pleistocene of Rome (1814); Frère Indes (1872), for the Quaternary paleontology and corresponding stratigraphy of the surroundings of Rome; Abbot C. Rusconi, for the fossil faunas and middle Paleolithic findings in Montecelio, near Rome. But a special mention has to be devoted to Luigi Ceselli and Gustav Bleicher, for their first acute and relatively modern observations and studies on the stratigraphy, fossil vertebrates and Paleolithic evidence (that they called “Archaeolithic”) of the Middle Pleistocene terraces of the lower Aniene valley, now Rome urbanized area.

Subsequently, we are already in the second half of the same century, when Giuseppe Ponzi covered the first chair of Geology at “La Sapienza” University of Rome, established by Pope Pio IX. His inaugural lecture dealt on the “prehistoric antiquity of human kind”, and was followed by several researches on Pleistocene localities and mammal fossil faunas in Latium. His contemporary paleoanthropologist and prehistorian Giustiniano Nicolucci, on the chair of Anthropology at the University of Naples (Regno delle Due Sicilie), was the first to find and recognise the Acheulean levels and relative faunal assemblages in Southern Latium. At the same time, Michele Stefano De Rossi reported about Paleolithic, Neolithic, and prehistoric localities and faunal remains in the region, while the baron Anca from Palermo was the first that clearly distinguished the chronological difference between the fluvial gravels respectively below and above the volcanic horizon constituted by the so-called “tufo litoide” (i.e. rocky tuff), consolidated ash-flow from the Latian-Albano volcano, near Rome.

Between the end of the 19th and the first half of the 20th centuries, it has to be recalled the vast amount of efforts representing the foundations for the development of our knowledge on the Pleistocene in Italy. Particularly we cannot forget to mention the work made by Terrigi, with his micropaleontological analysis of the first well-drillings made within the soil of Rome; by Cerulli-Irelli, for the Plio-Pleistocene malacology of Monte Mario (Rome); by Tuccimei, Mantov ani, and Portis, that produced paleontological and stratigraphic studies of the Campagna Romana and the Sabina (Northern Latium); as well as on Villafranchian faunal remains in sites North and North-West of Rome. A special mention has to be done of the huge geo-paleontological literature produced by R. Meli (1868-69), E. Clerici (1888), and G. De Angelis d’Ossat, the well known “trio” of geologists and palaeontologists of the Pleistocene in Latium, who we are in debt with for the innumerable data on several localities and geo-paleontological deposits. We recall, in particular, the intense scentific discussions between Terrigi and Clerici about their diverse interpretations given to stratigraphic subjects. And we do not forget the studies by both Don Vito Zanon, on diatoms in the surroundings of Rome, and Ugo Rellini, thatwas the first to recognise the great antiquity of the Paleolithic without bifacies that preceded the Acheulean. In 1932, he associated these archaic artifacts with the well differentiated and more ancient faunas than those of the Middle Pleistocene: he referred to this Paleolithic facies as “Preamigdaliano” (i.e. before the bifaces, or “amigdale”).

In addition, G. d’Erasmo left extensive paleontological studies on the large mammals contemporaneous of the Acheulean assemblages in the valleys of the rivers Liri and Sacco in Southern Latium. Even more widespread are the rsearches by Aldobrandino Machi, Gian Alberto Blanc, Carlo Alberto Blanc, and Luigi Cardini, about paleontology and prehistory in various Italian regions (Liguria, Tuscany, Apulia, etc.), including Latium; by both Giuseppe and Sergio Sergi and by Antonio Ascenzi, ancient human fossil specimens (particularly Neandertals); by Livio Trevisan, for the paleontology of the Elephants of Latium and the associated geo-stratigraphy; by EzioTongiorgi, for his paleobotanical studies. The list could follow, but this brief historical profile has to be concluded bringing to our memory that all these individual explorations and studies found a common home - already at the beginning of the last century - with the institution of the “Committee for the Research of Human Paleontology in Italy” in 1912, that gave a clear indication in terms of scientific and naturalistic planning of Quaternary researches in our country. In 1927, this committee became the present “Italian Institute of Human Paleontology”, whose activity is mainly devoted to excavations and researches in Italy, abroad, and particularly in Latium, Southern Latium being now its main interest.

REFERENCES

Brocchi, G.B. 1814. *Conchiliologia fossile subappennina*. Milano.

Clerici, E. 1888. Sopra alcune specie di felini della caverna del Monte delle Gioie presso Roma. *Boll. R. Comit. Geol.* (2 s.), 9, 5-6: 149-167.

Indes, Frère 1872. Paléontologie quaternaire de la Campagne Romaine. *Mater. Hist. Primit. Nat. de l'Homme* 3. Toulouse .

Kircher, A. 1665. *Mundus subterraneus*. Amsterdam.

Kircher, A. 1671. *Latium*. Roma.

Meli, R. 1868-69. Molluschi terrestri e d'acqua dolce, rinvenuti nel tufo litoide della Valchetta presso Roma. *Boll. Soc. Geol. Fr.* 1-11.

Mercati, M. 1574 *Metalloteca Vaticana*. Roma (Lancisi G.M., Roma 1717).

New data on the diversity of Elephants (Mammalia, Proboscidea) in the Early and early Middle Pleistocene of France

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SUMMARY: The remains of elephants are relatively scarce in Western Europe especially during the Early Pleistocene. The excavations of Ceyssaguet and Soleilhac (Haute-Loire, France) yielded a set of elephant teeth and bones, which belong to *Mammuthus* and *Palaeoloxodon* group. The majority of bones from Ceyssaguet (dated at 1.2 Ma.) are those of *Mammuthus meridionalis* but a very few bone legs belong probably to the *Palaeoloxodon* group. On the other hand the majority of elephant finds from Soleilhac belong to *Palaeoloxodon antiquus*. Nevertheless some teeth could be assigned to *Mammuthus meridionalis*.

1. INTRODUCTION

1.1 Review of Pleistocene Elephant species from Western Europe

Two groups of elephants are known from Western Europe: the *Mammuthus* group and *Palaeoloxodon* group. The first one contains three subgroups: *Mammuthus meridionalis* (with three subspecies: *Mammuthus meridionalis gromovi, Mammuthus meridionalis meridionalis* and *Mammuthus meridionalis vestinus*); *Mammuthus trogontherii* (which appears at the beginning of Galerian) and the later is *Mammuthus primigenius* (Palombo 1995). The group of *Palaeoloxodon* shows also many species and subspecies. However, Todd & Roth (1996) recognise the following three genus: *Loxodonta, Elephas* and *Mammuthus*.

2. ELEPHANTS SPECIES FROM FRANCE

2.1 Description of elephant remains from Ceyssaguet

Ceyssaguet is an important paleontological site localised on the outside of the Beneria volcano (Haute-Loire). Its excavation by Mrs M.F. Bonifay (1983-1997) yielded unfortunately only postcranials bones of elephants. The age of the site (by K/A) is estimated at 1.2 Ma. The most part of fossils provides from legs either found connected or partly dissociated. Our study of those fossils showed the possible presence of two elephants species: *Mammuthus meridionalis* in level 2 (the majority of bones) and probably *Palaeoloxodon antiquus* in level 3.

The humerus from level 2 are flattened transversely and present a triangular section, which characterised those of *Mammuthus*. On the fourth carpal bone the higher facet for pyramidal and the lower one for metacarpal bone V touched together along the external edge over a big length. Carpal bone III has a divided trapezoidal facet. Two complete tibias (both belong to adults animals) had the same morphology but they are different by measurements. This is due to the sexual dimorphism (Haynes 1991, Averianov 1996). In fact, male has the biggest total length of tibia (915 mm) and female has the smallest one: 694 mm (Fig. 1). Their proximal transverse diameter are respectively 313 mm /246 mm and their proximal antero-posterior diameter are 223 mm /199 mm. The distal ends have respectively the following dimensions: transversal diameter: 234/190 mm and the antero-posterior one: 214/167 mm.

This measurements are more close to those of *Mammuthus* from Aquila (total length: 860/850 mm) than to those of *Palaeoloxodon antiquus* from Upnor (which has a total length of 1020 mm). Our complete astragalus has the big height of 156 mm and the broad of 176.6 mm. The metatarsal III has a total length of 138 mm, however metatarsal IV is the biggest with 147 mm of total length.

The bones which belong to the *Palaeoloxodon* group are scarce (some fragments of posterior leg). Nevertheless they have similar morphology with the later group. A proximal fragment of tibia has a striking and straightforward crest. Moreover, some fibulas are different from those of the *Mammuthus* group of the site (Aouadi 1997; Aouadi & Bonifay 1998).

2.2 Description of elephant remains from Soleilhac

A lot of cranial and bone remains are yielded from the excavations of Soleilhac. The age of the site is 930000 years (Bonifay 1996).

Three complete tusks have their length between 1.87 and 2 m. They are straight which characterised *Palaeoloxodon* group. Measurements and features of molars are those of Lister (1996). Teeth are very height and narrow, the enamel is thin (Tab. 1).

Soleilhac teeth are similar in morphology with those of *Palaeoloxodon antiquus* from Chatelard (Beden 1969).

According to biometrics characteristics of teeth we could attribute the majority of them from Soleilhac to the species: *Palaeoloxodon antiquus.*

Metacarpal IV has the length of 205 mm and a proximal broad of 115.8 mm.

Besides the enormous remains of the *Palaeoloxodon* group, some tusks, milk teeth and legs present the type morphology of the *Mammuthus* group. Tusks are strongly curved and twisted. Teeth are broad (width of upper M2=93,8 mm) with low-crowned and thick enamel (thickness of enamel of upper M2=3.52 mm). These are characteristics of *Mammuthus meridionalis* (Lister 1996). The glenoid cavity of scapula, not very deep, has the dimensions of 189 mm (long) and 122.6 mm (wide). The radio-cubitus presents the morphology of *Mammuthus* genus with a regular surface of olecrane and with bowed olecranon on the lateral side. Its length (measured between the distal end and the olecrane) is about 87.5 cm. Hence we can confirm the presence of an evolved form of *Mammuthus meridionalis* at the site.

Tab.1 - Dimensions (in mm) of teeth of *Palaeoloxodon antiquus* from Soleilhac. (-): broken tooth.

***Palaeoloxodon antiquus* from Soleilhac**	M3 N=3 N=3	M2 N=3 N=2	M1 N=1 N=1	ML4 N=2 N=1
Lamellae number	13-21 8-14	14-16(-) 10-11	10 7(-)	10 3(-)
Length	221.1-334 175-231	179.2-229.1 189.8-197.9	175 100	129.3-135.3 55
Width	84.3-101.2 77.2-80.6	74-79 68.2-70	70.4 53.5	58.5-58.8 49.2
Height	180-212.7 146-161	145-149.5 (-)	(-) 98(-)	75.4-90 30(-)
Laminar frequency index	5.75-6 5-6	6-7 5.5-6	6 7	8 8
Thickness of enamel	2.6-2.72 2.5-3.04	2.64-2.92 2.21-2.35	2.58 2.92	2.16-2.21 1.42

Fig.1 - *Mammuthus meridionalis* from Ceyssaguet: Tibiae in dorsal view
a: left tibia of male, b: left tibia of female.

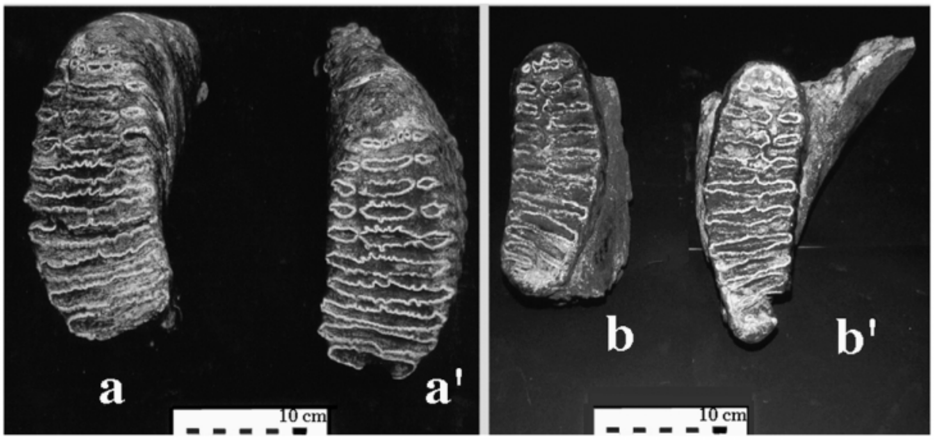

Fig.2 - *Palaeoloxodon antiquus* from Soleihlac: Teeth Upper M3 (a and a'), lower M2 (b and b').

3. CONCLUSIONS

To sum up we may state that the group of *Mammuthus* and the group of *Palaeoloxodon* lived together during the end of early and early middle Pleistocene but with the dominance of the first group during the end of the lower Pleistocene then by the second during the beginning of the middle Pleistocene in France. The lack of teeth don't allow us to give a specific level to the elephants remains from level 2 from Ceyssaguet site but we can confirm that they belong to the *Mammuthus* group whilst elephants' remains from level 3 belong probably to the group of *Palaeoloxodon*. The majority of elephants' fossils from Soleilhac are those of *Palaeoloxodon antiquus*. Nevertheless some tusks and teeth belong to *Mammuthus meridionalis*.

4. REFERENCES

Aouadi, N. 1997. *Méthodes d'étude des Proboscidiens: applications à Ceyssaguet et Soleilhac (Haute-Loire)*. Mém.D.E.A., Univ. Aix-Marseille I.

Aouadi, N. & Bonifay, M.F. 1998. Études paléontologique et taphonomique de restes de Proboscidiens (Ceyssaguet, Haute-Loire). *Bull.Mus.Anthropol.Préhist*. 39: 18-27.

Averianov, A.O. 1996. Sexual dimorphism in the mammoth skull, teeth and long bones. In Shoshani J., Tassy P. (eds.), *The Proboscidea. Evolution and palaeoecology of Elephants and their relatives*: 260-269. Oxford: University Press.

Beden, M. 1969. Étude et reconstitution des restes de *Palaeoloxodon (Elephas) antiquus* du Chatelard (Charente). *Bulletin des Sciences de la Terre de l'Université de Poitiers* 10: 45-53.

Bonifay, M.F. 1996. The importance of mammalian faunas from the early middle Pleistocene of France. In Turner A. (ed.), *The early middle Pleistocene in Europe*, (Proceedings of the SEQS Cromer Symposium - Norwich-September 1990): 255-262. Rotterdam, Balkema.

Haynes, G. 1991. *Mammoths, mastodonts, and elephants: biology, behavior, and the fossil record*. Cambridge/New york: Cambridge University Press.

Lister, A.M. 1996. Evolution and taxonomy of Eurasian mammoths. In Shoshani J., Tassy P. (eds.), *The Proboscidea. Evolution and palaeoecology of elephants and their relatives:* 203-213. Oxford: University Press.

Palombo, M.R. 1995. Gli Elefanti del Pliocene superiore e del Pleistocene dell'Italia centrale peninsulare: alcune considerazioni. *Studi geologici Camerti, Volume speciale B (1994)*: 447-457.

Todd, N.E. & Roth, L.V. 1996. Origin and radiation of Elephantidae. In Shoshani J., Tassy P. (eds.), *The Proboscidea. Evolution and palaeoecology of elephants and their relatives*: 193-202. Oxford: University Press.

Proboscidea of the Greek Pliocene-Early Pleistocene faunas: biochronological and palaeoecological implications

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SUMMARY: Proboscidea constitute a very important element of the Neogene and Quaternary continental faunas of Greece, being present in almost every fossil mammal locality. Isolated, fragmentary findings are numerous, all over area. Nevertheless, well-preserved elephant remains are rather sporadic. The most common Pliocene species is *Mammuthus meridionalis*, which coexisted with *Anancus arvernensis* during the Late Pliocene. Some *Mammut borsoni* findings come from Early Pliocene deposits. During the Early Pleistocene only *Mammuthus meridionalis* exists in the fossil record. The palaeoecological and biochronological implications of these species are discussed.

1. INTRODUCTION

The Proboscidea have developed an incredible diversity of forms in the Eurasian Neogene and Quaternary faunas, adapted to a variety of palaeoenvironments. Proboscidean remains are known in the Greek fossil record from the Middle Miocene to the Holocene times, attributed to several continental and insular forms. However, their biochronological and palaeoecological relationships have been barely studied. Recently, Doukas & Athanassiou (in press) gave an extensive review of the Pliocene and Pleistocene Proboscidea from Greece. The present article deals with the proboscidean remains that are of known stratigraphical context and come from Pliocene–Early Pleistocene faunas of this geographic area. Short systematic descriptions of less known or even unknown specimens are followed by biochronological and palaeoecological remarks, in order to investigate the significance of proboscidean remains in the Pliocene and Early Pleistocene fossil record.

2. PALAEONTOLOGY

2.1 *Mammut borsoni* (Hays 1834)

This mammutid mastodont is rare in Greece, usually known from isolated fragmentary material. All findings come from Northern Greece (Tsoukala 2000; Doukas & Athanassiou in press). Mitzopoulos (1967) reports the presence of the species in Vathýlakkos (valley of Axiós), but there is no biochronological information about this finding. Dermitzakis *et al.* 1982 also mention its presence at two localities in Neápolis district (Grevená basin, W. Macedonia). Although the exact age of the sites is unknown, Pliocene and Pleistocene deposits, overlying molassic sediments, cover the area.

Tsoukala (2000) describes a partial skeleton attributed to this species, including a complete mandible and two impressively long tusks, found in Miliá (Grevená). According to the author the locality could be of Ruscinian age (MN14–MN15). Nevertheless, the lithological character of the deposits in the context of the regional geology rather points to a somewhat younger age (personal data). A dating in MN16 is also possible (as *Mammut borsoni* is present in this zone too — Mein 1990), which seems to fit pretty well with the advanced features of the Miliá mastodont.

2.2 *Anancus arvernensis* Croizet & Jobert, 1828

This bunodont gomphotheriid with tetralophodont molars is rather frequent in the Greek fossil record (Doukas & Athanassiou in press). Nevertheless, among the numerous evidences of its presence only a few are of known stratigraphical context and therefore could offer accurate chronological data.

Symeonidis & Tataris (1983) describe a complete, very well preserved mandible from Sésklo (Thessaly) with both M_3 *in situ*. It is a massive specimen of an aged individual. Its teeth have the typical anancoid cusp pattern. Later on, Athanassiou (1996) describes a partly preserved skull without teeth, from the same locality, that belongs to a large male (as deduced by the large tusk sheaths). The skull is high with short snout. The tusk sheath is almost horizontal. The nasal opening is placed above and behind the orbit, which is rather large and it is placed at the front of the skull. The occipital region is very large and almost flat, with strong occipital crest. The frontal region is markedly convex. The basal region and the dentition are not preserved. Measurements of this specimen are given in table 1.

Fig.1 - Geographical distribution of the Pliocene–Early Pleistocene Proboscidean findings in Greece. Open circles indicate *Mammuthus meridionalis*, slashed circles indicate *Anancus arvernensis* and crossed circles indicate *Mammut borsoni*.

Tab.1 - Cranial and dental measurements of *Anancus arvernensis* from several Greek localities. Measurements in parentheses are approximate.

Anancus arvernensis Skull	cm
Cranial DAP	93
Distance between the inion and the upper margin of the nasal opening	(30)
Total height	50
Length of the premaxillar bones	53
Height of the orbit	(12)
Diameter of the tusk sheath	(17)

A. arvernensis Teeth	M^1 mm	M^2 mm	M^3 mm
DAP	105	—	242
DT	65	66	87–98
	M_1 mm	M_2 mm	M_3 mm
DAP	—	135–144	204–242
DT	—	77	80–98

Sésklo yielded a rich mammal fauna that has been dated by Athanassiou (1996) in the lower MN17 (Late Pliocene).

Steensma (1988) reports the presence of *Anancus arvernensis* at Klíma and possibly at Polýlakkon (North-western Macedonia). The poor faunal content of both localities does not allow any accurate biochronological inference. According to the author, the first locality may correspond to Early Pliocene (based on a correlation to a marine fauna), while the second one to the Late Pliocene (the presence of a relatively small and slender *Equus*, very similar to that from Gerakaroú, support this dating).

Theodorou *et al.* (2000) describe a juvenile cranial part from Apolakkiá (Rhodes Island) with tusks, M^1, as well as the erupting M^2 of both sides. The straight tusks and alternating cusps of the cheek teeth characterise this specimen. The authors give a Pliocene age to the specimen, but they note that it comes from a higher horizon, which overlies already known fossiliferous levels of Apolakkiá Formation of probably MN15 age. This suggests that the age of the *Anancus* from Apolakkiá could be confined to the Late Pliocene.

2.3 *Mammuthus meridionalis* (Nesti 1825)

This species is typical of the “Villafranchian” faunas of Greece, and it is found in most fossil mammal localities of this stage (Doukas & Athanassiou in press). Also in this case, most of the available findings are scanty, mainly representing isolated molars. The available molars are mostly M_3 that are 172–320 mm long, 84–118 mm wide and 80–155 mm high. They consist of $11^{1}/_{2}$ –14 plates, and they have 4–5 plates per 10 cm of tooth length. These measurements are inside the variation of the species, given by Maglio (1973).

Steensma (1988) describes some fragmentary dental and osteological remains attributed to *M. meridionalis* from the localities of Líbakos, Kapetánios, Polýlakkon and Aliákmon Q-Profil (West Macedonia). The first locality is dated in the Early Pleistocene (possibly MNQ20), while a similar age is also probable for Kapetánios and Aliákmon Q-Profil. Polýlakkon is dated in the Late Pliocene.

Athanassiou (1996) describes *M. meridionalis* remains from the Late Pliocene (lower MN17) locality of Sésklo (Thessaly). A partial tusk from Sésklo has a maximal diameter of 130 mm and a retained length of 121 cm; the total length must have been much more than 200 cm. The specimen shows a weak torsion, which is characteristic of the species (Maglio 1973). Postcranial material is known from Sésklo and Gerakaroú and it comprises mainly carpal bones. The carpals from Sésklo are very large (Tab. 2).

The few postcranial remains from Gerakaroú (trapezium, GER-341, scaphoid, unciform, magnum, GER-353a, b, c, and phalanx I ant.$_{III}$, GER-342) indicate metrical and morphological similarities with *Mammuthus meridionalis* (Tab. 2). According to the rest of the fauna the locality of Gerakaroú is dated at the very end of Pliocene (upper MNQ18 — Koufos & Kostopoulos 1997).

A single elephant specimen is also known from the late Early Pleistocene locality of Apollonía (Mygdonía basin, N. Greece) (Koufos & Kostopoulos 1997). It is a maxillary fragment with dp^2–dp^3, belonging to a young individual. dp^2 is 21.5 mm long, 16.7 mm wide and oval-shaped, consisting of four plates. dp^3 is relatively elongated and narrow (L_{max} = 80.5 mm, $W_{max} \approx 40$ mm), it consists of eight plates (lamellar frequency = 10) and it has rather thin enamel (2.0–2.5 mm). These morphological and metrical characters place this specimen in an intermediate position between *Mammuthus meridionalis* and later forms (*Mammuthus trogontherii*), but a specific determination is quite difficult for the moment.

The Middle–Late Pleistocene locality of Megalópolis (Peloponnesus) is rich in proboscidean material, described by Melentis (1961, 1963). The author refers some specimens to *M. meridionalis*, but there are many doubts about the presence of the species there, as the studied molars are relatively narrow and hypsodont (hypsodonty index > 260 for a M^3). Sondaar & Boekschoten (1967) interpret the material from Megalópolis as representing only the species *Elephas antiquus* and *Mammuthus primigenius*.

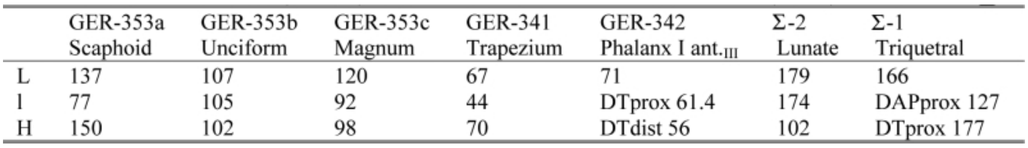
3. BIOCHRONOLOGY - PALAEOECOLOGY

The Early Pliocene (Ruscinian) faunas are not common in Greece, and only a couple of them include Proboscidean remains. *Mammut borsoni*, a relatively rare species, marks the Early Pliocene faunas of Europe. Its presence in the Pliocene deposits of N. Greece is well documented. Despite the absence of well-dated findings, the species seems to survive until about the middle of the Pliocene (MN16) and it disappears thereafter.

Anancus arvernensis is the last mastodont that lived in Europe. It coexisted with *Mammut borsoni* during the Early Pliocene and *Mammuthus meridionalis* during the Late Pliocene. The available Greek material generally represents the Late Pliocene representatives of the species (though there is no dating evidence for many isolated finds). This fact could be attributed to the scarcity of Ruscinian localities in Greece. The occurrence at Klíma could be one of the oldest in Greece, if the correlation of the site with marine Lower Pliocene deposits (Steensma 1988) is accurate. The latest well-documented occurrence of the species in Greece is in the Late Pliocene locality of Sésklo.

Mammuthus meridionalis is the first representative of the family Elephantidae in Greece. It appeared during the Late Pliocene (MN17) and it coexisted for a short time period with *A. arvernensis*. This co-occurrence is

Tab.2 - Measurements (in mm) of *M. meridionalis* from Gerakaroú (GER) and Sésklo (Σ).



	GER-353a Scaphoid	GER-353b Unciform	GER-353c Magnum	GER-341 Trapezium	GER-342 Phalanx I ant.$_{III}$	Σ-2 Lunate	Σ-1 Triquetral
L	137	107	120	67	71	179	166
l	77	105	92	44	DTprox 61.4	174	DAPprox 127
H	150	102	98	70	DTdist 56	102	DTprox 177

found at Sésklo, though it is not absolutely sure that the findings of the two species come from exactly the same stratigraphic level. *Anancus arvernensis* and *Mammuthus meridionalis* may also co-occur at Polýlakkon, as the former is possibly present in this locality (Steensma 1988).

At the very end of Pliocene and during the Early Pleistocene *Mammuthus meridionalis* appears to be the only representative of Proboscidea. At the beginning of Middle Pleistocene the species is transitionally replaced by new, more advanced forms of the same lineage, while more or less at the same time *Elephas antiquus* appears in Europe.

The successive changes in the proboscidean species plausibly reflect climatic and environmental shifts during the considered time span. The mastodonts, *Mammut* and *Anancus*, were browsers, as inferred by the bunodont morphology of their molars, and inhabited forest or woodland environments. The appearance of *Mammuthus meridionalis* may mark a transition from a rather wooded environment to a more open one, as this animal was less specialised and more broadly adapted feeder (Kurtén 1968). This gradual environmental change caused a trend of the *Mammuthus* lineage during the Lower Pleistocene towards more hypsodont molars with more densely packed plates. The associated mammal faunas of Late Pliocene – Early Pleistocene age also indicate open and rather dry habitats, as the dominant families are the Equidae and Bovidae, while forest elements, as Cervidae or Suidae, are rare.

4. REFERENCES

Athanassiou, A. 1996. *Contribution to the study of the fossil mammals of Thessaly*. PhD thesis. University of Athens (in Greek).

Dermitzakis, M.D., Symeonidis, N.K., de Boer, L.E.M. & Sondaar, P.Y. 1982. *The evolution of the elephants*. Athens: Editions of the Laboratory of Geology and Palaeontology, University of Athens (in Greek).

Doukas, C.S. & Athanassiou, A. in press. Review of the Pliocene and Pleistocene Proboscidea (Mammalia) from Greece. *2nd Intern. Mammoth Congr.* (Rotterdam, 1999). *Deinsea*, 8.

Koufos, G.D. & Kostopoulos, D.S. 1997. Biochronology and succession of the Plio-Pleistocene macromammalian localities of Greece. *BiochroM '97*, (Montpellier), *Mém. Trav. E.P.H.E. Inst. Montpellier* 21: 619-634.

Kurtén, B. 1968. *Pleistocene Mammals of Europe*. London: Weidenfeld and Nicolson.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.* 63 (3): 1-126.

Mein, P. 1990. Updating of MN zones. In E.H. Lindsay, V. Fahlbusch & P. Mein (eds.), *European Neogene Mammal Chronology*: 73-90. New York: Plenum Press.

Melentis, J.K. 1961. Die Dentition der pleistozänen Proboscidier des Beckens von Megalopolis im Peloponnes (Griechenland). *Ann. Géol. Pays Hellén* 12: 153-262.

Melentis, J.K. 1963. Die Osteologie der pleistozänen Proboscidier des Beckens von Megalopolis im Peloponnes (Griechenland). *Ann. Géol. Pays Hellén* 14: 1-107.

Mitzopoulos, M.K. 1967. *Zygolophodon borsoni* und *Anancus (Bunolophodon) arvernensis* aus dem Oberpliozän von Griechenland. *Ann. Géol. Pays Hellén* 18: 436-446.

Sondaar, P.Y. & Boekschoten, G.J. 1967. Quaternary Mammals in the South Aegean island arc; with notes on other fossil Mammals from the coastal regions of the Mediterranean. *Proc. Koninkl. Neder. Akad. Wet* 70 (5): 556-576.

Steensma, K.J. 1988. *Plio-/Pleistozäne Großsäugetiere (Mammalia) aus dem Becken von Kastoria / Grevena, südlich von Neapolis – NW Griechenland*. Inaugural-Dissertation. Technische Universität Clausthal.

Symeonidis, N.K. & Tataris, A. 1983. The first results of the geological and palaeontological study of the Sesklo basin and its broader environment (Eastern Thessaly, Greece). *Ann. Géol. Pays Hellén* 31: 146-190 (in

Greek and German).

Theodorou, G., Spjeldnaes, N., Hanken, N.M., Lauritzen, S.E., Velitzelos, E., Athanassiou, A. & Roussiakis, S. 2000. Description and taphonomic investigations of Neogene Proboscidea from Rhodos, Greece. *Ann. Géol. Pays Hellén* 38 (C): 133-156.

Tsoukala, E. 2000. Remains of a Pliocene *Mammut borsoni* (Hays 1834) (Proboscidea, Mammalia), from Milia (Grevena, W. Macedonia, Greece). *Ann. Paléont*, 86 (3): 165-191.

Plio-Pleistocene Proboscidea and Lower Palaeolithic bone industry of southern Latium (Italy)

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SUMMARY: Elephant remains were first reported from the Valle Latina, in inner southern Latium, in 1864, by O.G. Costa. Since, they have been discovered at some 20 sites, ranging in age from the Middle Villafranchian (Costa S. Giacomo, with both *Anancus arvernensis* and *Mammuthus* (*Archidiskodon*) *meridionalis*), to the Late Pleistocene (S. Anna near Veroli, with *Mammuthus primigenius*). Most of the relevant faunal record, however, is of Middle Pleistocene age, and is characterised by *Elephas antiquus*. This species was discovered, most notably, at several archaeological sites, in association with Acheulean industry, starting with Fontana Ranuccio near Anagni, which is dated to c. 450 ka bp by K/Ar. At such sites, bones of *Elephas antiquus* were sometimes knapped to produce bone tools, including bone handaxes.

1. PROBOSCIDEA IN THE VALLE LATINA

The quaternary deposits in the Valle Latina are rich in faunal finds. These include frequent elephant bones that have been the subject of scientific interest since the second half of the nineteenth century.

The first reported elephant fossils (Costa 1864) had been found in a cave near Cassino. Nicolucci (1883) reported elephant finds from all over the region. In 1889 Cacciamali presented his paper on the elephant fossils of Aquino and Arpino.

The earliest proboscidean remains in the region were retrieved from sandy fluvial deposits at Costa S. Giacomo (*sensu* Gliozzi *et al.* 1997). The finds are associated with the Middle Villafranchian fauna of Anagni. A lower left molar has been attributed to *Anancus arvernensis*. A further molar fragment with three plates has been identified as *Mammuthus* (*Archidiskodon*) *meridionalis*. The fauna includes *Macaca* cfr. *M. florentinus*, *Stephanorhinus* cfr. *S. etruscus*, *Equus stenonis*, *Pseudodama* cfr *P. lyra*, *Eucladoceros* cfr. *E. tegulensis*, *Leptobos* sp., *Gazella borbonica*, *Gazellospira torticornis*, *Canis* cfr. *C. etruscus*, *Vulpe*s cfr. *V. alopecoides*, *Hyaenidae* gen. sp. indet. and *Hystrix* cfr. *H. refossa* (Cassoli & Segre Naldini 1993; Palombo *et al.* in press a).

An upper M3 belonging to a *M.* (*A.*) *meridionalis* was discovered during the Campo del Conte TAV railway line excavations on the left bank of the Sacco river (Capozza, this volume). The advanced morphology places it in the Early Galerian. Various faunal and scanty lithic remains were retrieved from the sequence. The fauna includes remains of cervidae, pachyderms and various species of bird. An upper M2 belonging to *Elephas antiquus* (Palombo *et al.*, in press b) was also recovered.

A tusk attributed to *M.* (*A.*) *meridionalis*, sinusoidal curved, was found at Fosso Meringo (Pofi). It is 2.9 m long and has an approximate circumference of 0.58 m. There were Miocene clays and sandstone blocks at the bottom of the

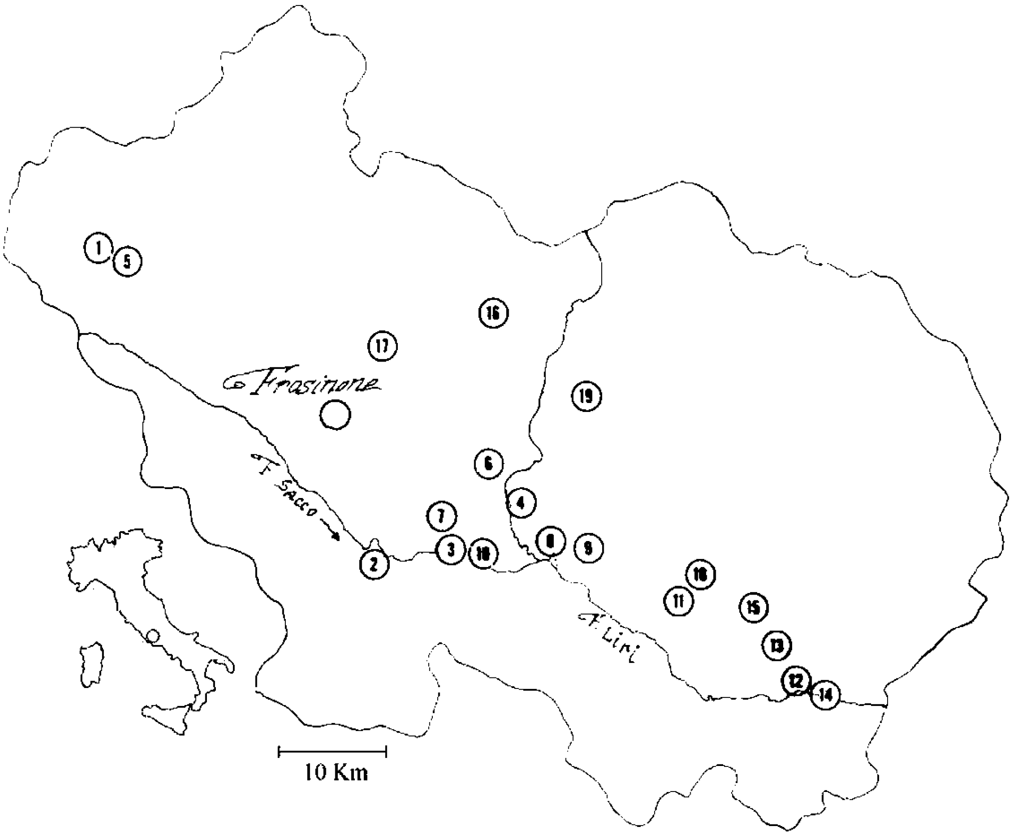

Fig.1 - Site distribution: 1, Anagni-Costa S. Giacomo; 2, Campo del Conte; 3, Pofi-Fosso Meringo; 4, Ceprano-Madonna del Carmine; 5, Anagni-Fontana Ranuccio; 6, Strangolagalli-Pietra Cantone; 7, Pofi-Cava Pompi; 8, Arce-Isoletta; 9, S. Giovanni Incarico-Lademagne; 10, Ceprano-Campogrande e Colle Avarone; 11, Pontecorvo-Cave Panzini; 12, Pignataro Interamna-Podere Tiseo; 13, 14, Pignataro Interamna-Termine e Panaccioni; 15, Piedimonte S. Germano-Ponte Castelluccio; 16, Veroli-Casamari; 17, Veroli-S.Anna; 18, Aquino; 19, Arpino.

stratigraphic sequence covered by an alternating sequence of layers of Lower Pleistocene gravels. These were sealed by layers of peat, gravels and sands with volcanic mineral inclusions. The tusk lay in sandy sediments, with the presence of altered augite. The latter could be associated with distant volcanic activity, prior to that of the Ernici district. The upper part of the sequence included flake and pebble flint artefacts. Of interest among the bone industry artefacts is a point worked from a bone flake. It has striking platform, one side has been retouched by deep notches and the platform has been whittled down with burin-like removal (Biddittu 1974).

Elephas antiquus finds came to light in 1899 in gravel flood deposits at Ceprano. They include the pelvis, a radius, ulna, a femur, the glenoid socket, the lower jaw with molar fragments and various other fragments of molars and tusks. They are kept in the Madonna del Carmine sanctuary. The fragment of molar that has been examined has plates with a loxodont *sinus* and a central v-shaped. The enamel varies in thickness from to 2.2 and 3.3 mm (Celletti 2000).

Numerous elephant remains have been collected on the Fontana Ranuccio site (Anagni) (FU) explored by the Istituto Italiano di Paleontologia Umana (Biddittu *et al.* 1979). After K-Ar, dating the archaeological layer is 458,000 years old, bracketed by volcanic deposits dating back to 528,000 and 366,000 years ago respectively. The faunal record includes *Elephas antiquus*, *Stephanorhinus* cfr. *S. hemitoechus*, *Equus* sp., *Sus scrofa*, *Hippopotamus* ex. gr. *H. amphibius*, *Cervus elaphus eostephanoceros*, *Capreolus capreolus*, *Dama clactoniana*, Megacerini gen. spec. indet., *Bos primigenius*, *Ursus deningeri*, *Cuon* cfr. C. *alpinus* and *Panthera leo spelaea* (Cassoli & Segre Naldini 1993; Palombo *et al.* in press a). The elephant molars are elongated and tapering with a central v-shaped fold on both sides of the enamel loop. The lithic implements includes a few lava and flint bifaces as well as small-sized flake artefacts. There are several bone artefacts, mostly made on the diaphysis of elephant bones, including bone bifaces (Biddittu & Bruni 1987). Four human teeth were found, two molars and two incisors (Ascenzi & Segre 1996).

An *E. antiquus* lower jaw and a fragment of humerus from Pietra Cantone (Strangolagalli) may also belong to Fontana Ranuccio FU. The remains came to light twenty years ago during agrarian work. The molars appear to be archaic given the enamel thickness (between 2.6 and 3.1 mm) and lamellar frequency (6) (Celletti 2000).

The Istituto Italiano di Paleontologia Umana carried out excavations at the Cava Pompi site of Pofi in 1961 and 1976. A sequence of deposits from Pofi's polygenic volcano was recorded. These lay beneath a sequence of redeposited volcanic sands with lithic industry and faunal remains as well as human bones (tibia and ulna). The faunal record includes *Macaca florentinus*, *Elephas antiquus*, *Stephanorhinus* sp., Megacerini sp. gen. indet., *Dama* cfr. *D. clactoniana* and *Cervus elaphus* (Biddittu & Segre 1978). The lithic assemblage includes both lava and flint artefacts. The former consists of choppers, denticulates and flakes. The flint artefacts are small flake i,plements. There are also artefacts worked from the diaphysis of big mammals including elephants. The stratigraphic position suggests an age between 350 ka and 400 ka BP.

In the second half of the nineteenth century G. Nicolucci quoted elephant finds from Isoletta (Arce). In 1999 the Soprintendenza Archeologica del Lazio excavated a sequence of fluvial and lacustrine sediments along the railway line of the new "TAV" high speed train. Two main units were recognized. The lower one yielded a few lithic scrapers and denticulates, and some bone tools. The faunal record includes *Elephas antiquus* (a skull, two jawbones and one femur), *Stephanorhinus* sp., *Equus ferus*, *Dama clactoniana*, *Megaloceros* cfr. *M. giganteus*, *Cervus elaphus* and *Castor* sp. A preliminary analysis of the pollen and macroflora suggests a temperate period with a moist climate followed by cold and arid conditions. There are various freshwater molluscs including *Unio* sp., *Pisidium* sp, *Dreissena* sp., *Pyrgula annulata* and *Theodoxus isseli*. The

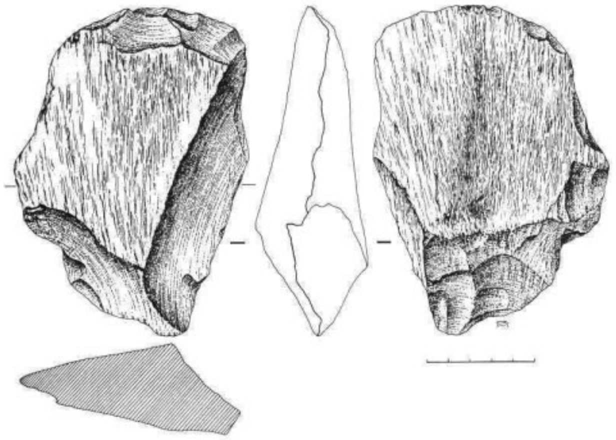

Fig.2 - S. Giovanni Incarico-Lademagne. Bone industry from the lower Acheulean level.

area was then probably partially covered by a lake, some 25 to 30 metres deep, where small reptiles, amphibians and fish lived. The fauna and flora of the lakeside ecosystem would have included hygrophyllus vegetation. The archaeological record includes flint flake artefacts and a bone scraper. Elephant molars were recovered from the sand and gravel layers and the lower silt deposits. The average enamel thickness is about 2 mm. The average laminar frequency on the upper molars is 6, whereas on the lower one it is 5.5. The aminochronological dating of an elephant molar gave an age of 385 ka bp.

The find record from the upper layers, Acheulean, includes both lithic and bone implements (bifaces, choppers, scrapers and denticulates). The faunal record includes *Stephanorhinus* sp., *Equus ferus*, *Cervus elaphus*, Megacerini gen. sp. indet., *Bos primigenius* (aminochronological dating of a molar gave an age of 174 ka) and *Canis lupus*. The *Elephas antiquus* remains included a skull, a coxal bone, a mandible with both M3 and a fragment of a mandible with a dp4. The laminae of the two M3 are consistently oval in form and lack the *sinus*. The laminar frequency is 5 and the average thickness of the enamel range from 1.6 to 2.4 mm. An *Elephas antiquus* foot in anatomical connection was recovered from the upper layers. A jaw fragment belonging to *M. trogontherii* was recovered from the earliest layers. The M2 are ovoid, the lamellar frequency is 5, the enamel thickness is 2 mm (Zarattini 1999; Celletti 2000).

The Lademagne site (S. Giovanni Incarico) two km east of Isoletta, two Acheulean deposits have been explored. The faunal record of the lower deposit includes *Elephas antiquus*, *Equus* cfr. *E. ferus, Hippopotamus* cfr. ex gr. *H. amphibius*, *Bos primigenius*, *Dama* cfr. *D. clactoniana*, *Cervus elaphus* and *Castor* sp.. Both *Castor* sp. and *Hippopotamus* cfr. ex gr. *H. amphibius* are not found in the upper deposit. Symmetrical bifaces are included in the lithic assemblage. These are manufactured either from calcareous rock or, more rarely, from flint and quartz. Heavy-duty choppers appear to be more frequent in the lower layers. There is also lithic industry on flakes and on bone.

Elephas antiquus teeth (M^3 and M^1) were found at Colle Avarone and Selvotta (Ceprano) associated to Acheulean industries. The record also includes *Stephanorhinus* sp. *Bos primigenius*, *Cervus elaphus*, *Cuon* sp, *Anser brachyrhyncus* and *Stercorarius longicaudatus.* The birds, as well as the presence of dhole, suggest a cold climate (Cassoli 1978), which might correspond to OIS 8. The lithic assemblage includes many limestone, flint and quartz bifaces. Evidence that elephant bone was worked is given by bone flakes with percussion scars and by a rib cut transversally and splintered (Biddittu & Segre 1982).

At Cava Panzini, a quarry exposed an archaeological deposit with an Acheulean industry associated to faunal remains (*Elephas antiquus, Stephanorhinus* sp., *Hippopotamus* cfr. ex gr. *H. amphibius, Equus ferus, Bos primigenius, Cervus elaphus, Megaceroides* cfr. *M. verticornis* and *Anser erythrophus* - Biddittu & Cassoli 1969). There is also evidence of flaked bone industry.

Two *Elephas antiquus* skulls were discovered at Pignataro Interamna: one is in the Natural History Museum of New York (Osborn 1942), the other in the Museum of Palaeontology of the University of Naples (D'Erasmo & Moncharmont Zei 1955). They were associated to *Stephanorhinus* sp., *Hippopotamus* ex gr. *H. amphibius, Bos primigenius, Cervus elaphus.* Two flint bifaces are also recorded (De Lorenzo & D'Erasmo 1932) as well as a bone tool on an elephant long bone diaphysis (Biddittu & Palombo 2000).

From the sand and gravel deposits at Ponte Castelluccio in Piedimonte S. Germano, the following taxa are reported: *E. antiquus, Equus sp., Cervus* sp. Other finds include a limestone biface and scanty bone artefacts (Biddittu & Segre 1976).

A mandible fragment with both M_2 was found in 1975 at S. Anna, in the Veroli area. The molars appear to be typical of *Mammuthus primigenius,* given enamel thickness (1.3 mm) and lamellar frequency (8). There is no stratigraphic control for the deposit, but an attribution to the Late Pleistocene might be suggested after comparisons with the Předmostí sample (Celletti 2000).

2. FINAL REMARKS

This review confirms the occurrence of various species of Proboscidea in southern Latium all over the Plio-Pleistocene. Bone flaking was performed to produce complex tools, such as scrapers and bifaces, well before 400 ka bp. Flaked bone tools, however, are not any more found at Late Pleistocene sites.

3. REFERENCES

Ascenzi, A. & Segre, A. G. 1996. Artefacts and human teeth at the Fontana Ranuccio Middle Pleistocene site (Central Italy). *Anthropologie* 34: 39-46.

Biddittu, I. 1974. Giacimento pleistocenico ad amigdale acheuleane nel territorio di Ceprano (FR). *Mem. Ist. It. di Paleont. Umana* 2: 61-67.

Biddittu, I. & Bruni, L. 1987. Il rinvenimento di una amigdala in osso del Paleolitico inferiore a Fontana Ranuccio (Anagni). *Latium* 4: 3-6.

Biddittu, I. & Cassoli, P.F. 1969. Una stazione del paleolitico inferiore a Pontecorvo in provincia di Frosinone. *Quaternaria* 10: 167-197.

Biddittu, I. & Segre, A.G. 1976. Giacimenti preistorici e quaternario della Provincia di Frosinone, *Boll. Ist. St. e Arte del Lazio Merid.* 9: 21-44.

Biddittu, I., Cassoli P. F., Radicati Di Brozolo F., Segre, A. G., Segre Naldini, E., Villa, I. 1979. Anagni a K-Ar dated lower and middle-Pleistocene Site, Central Italy: preliminary report. *Quaternaria* 21: 35-52.

Biddittu, I., & Segre, A.G. 1978. Paleolitico inferiore a Cava Pompi presso Pofi, Frosinone. *Quaderni Centro Studi Arch. Etrusco-Ital.* 1: 78.

Biddittu, I. & Segre, A.G. 1982. Utilizzazione dell'osso nel Paleolitico inferiore italiano. *Atti XXIII Riun. Sc. Ist. It. di Pr. e Prot.*: 90-105.

Biddittu, I. & Palombo, M. R. 2000. I nuovi resti di industria e fauna di Pignataro Interamna (Lazio meridionale), *Riassunti 3° Congr. AIAZ, 2-6 novembre 2000, Siracusa*: 7.

Cacciamali, G. B.1889. Gli elefanti fossili di Aquino. *Boll. Soc. Geol. It.* 9: 423-424.

Capozza, M. 2001. Microwear analysis of a *Mammuthus meridionalis* (Nesti 1825) molar from Campo del Conte (Frosinone, Southern Lazio, Italy). *This volume*.

Cassoli, P.F. 1978. L'avifauna pre- wurmiana di

Torre in Pietra. *Quaternaria* 20: 429- 440.

Cassoli, P. F. & Segre Naldini, E. 1993. Le faune di Costa S. Giacomo e Fontana Ranuccio. In S. Gatti *Dives Anagnia, Archeologia nella Valle del Sacco*: 30-38. Roma: L'Erma.

Celletti, P. 2000. Resti di proboscidati del Pleistocene medio e superiore delle valli del Sacco e del Liri (Lazio meridionale). *Tesi di laurea in Sc. Naturali, Università di Roma "La Sapienza"*. Unpublished.

Costa, O. G. 1864. Relazione intorno agli ossami fossili di Cassino e della Melfa. *Rend. R. Acc. Sc. fis. e mat.*, giugno 1864.

D'Erasmo, G. & Moncharmont Zei, M. 1955. Il cranio giovanile di *Elephas antiquus italicus* di Pignataro Interamna, nella valle del Liri. *Atti Ac. Sc. Fis. e nat.* 3: 1-32.

De Lorenzo, G. & D'Erasmo, G.1932. L'Uomo paleolitico e l'*Elephas antiquus* nell'Italia meridionale, *Atti R. Acc. Sc. fis. e mat.* 29, serie 2, n° 5.

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 in Italy. The state of the art. *Riv. It. Paleont. Strat.* 103: 369- 388.

Nicolucci, G. 1883. Note paleontologiche. *Mem. Soc. It. delle Sc.*, s. 3, vol 6.

Osborn, H. 1942. *Palaeoloxodon antiquus italicus* sp. nov. final stage in the *Elephas antiquus* phylum. *American Museum Novitates*: 460.

Palombo, M. R., Azanza B. & Alberdi M. T. in press a. Italian mammal biochronology from latest Miocene to middle Pleistocene: a multivariate approach. *Geologica Romana.*

Palombo, M. R., Magri, D., Molinaro, A., Pisano, P. in press b. The Pleistocene sequence of Campo del Conte (Lower Sacco Valley, Southern Latium). *Geologica Romana.*

Zarattini, A. (ed.) 1999. *Indagine geoarcheologica e paleoambientale (Isoletta, Arce)*. Tethys, unpublished report for Vianini SpA.

Functional morphology of small-sized deer from the Early and Middle Pleistocene of Italy: implication for paleolandscape reconstruction

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SUMMARY: The functional morphology of antlers, masticatory apparatus and appendicular skeleton of the early and middle Pleistocene small-sized deer *Pseudodama nestii* and ancient species of the genus *Dama* is regarded in the present paper. The revealed morpho-functional adaptations suggest *P. nestii* as an inhabitant of mountainous forests. *Dama eurygonos, D. eurygonos farnetensis* and *D. vallonnetensis* that form a phyletical lineage, inhabited open savanna-like landscapes and display gradual evolutionary changes in the direction of ritualised antlers and cursorial locomotion. The functional morphology and ecology of the studied deer suggest the changes of the ecological conditions during the late Villafranchian from mixed forest-savanna landscape to the more open and dry type of savanna, the savanna parkland and tree-shrub savanna.

1. INTRODUCTION

Cervids are an important back-ground faunal group represented by numerous species and well-preserved fossil remains and may be a valuable tool in the Villafranchian paleolandscape reconstruction. Several phylogenetical lineages of small-sized deer are recorded in the Early Pleistocene deposits of Italy. The first lineage contains a single species *Pseudodama nestii* (Azzaroli 1947) that is evolutionary close to recent representatives of the genera *Axis* and *Cervus*. *P. lyra* Azzaroli 1992 shows a rather early ontogenetical stage of antler development and should be considered as a junior synonym of *P. nestii* (Croitor in press). The second lineage includes ancient fallow deer *Dama eurygonos* Azzaroli 1947, a larger advanced subspecies *D. eurygonos farnetensis* Azzaroli 1992 and *D. vallonnetensis* (=*Cervus s.l. nestii vallonnetensis* de Lumley *et al.* 1988). The Villafranchian fallow deer are characterised by typical for *Dama* cranial morphology, however their antlers lack the distal palmation. Both *P. nestii* and *D. eurygonos* are descovered in the composition of the fauna from Figline (Tasso F.U.) (Croitor in press), dated by the beginning of early Pleistocene of Italy (Azzaroli 1992). *D. e. farnetensis* is the best represented species in the Farneta F.U. that is the next stage of the Villafranchian fauna development (De Giuli 1986). *D. vallonnetensis* is recorded in the latest Villafranchian – Postvillafranchian faunas of Italy and South France. In Italy, the remains of this deer are recorded in the composition of Pirro F.U. from Capena (reported as *Dama nestii eurygonos* by Petronio 1979) and Pirro Nord (= *"Dama" cf. nestii*: De Giuli *et al.* 1987, = *Pseudodama farnetensis*: Colucci 1993). Pfeifer (1997) and Di Stefano & Petronio (1998) made recent attempts of systematical revision of the Villafranchian small-sized deer based mainly on the morphology and proportions of appendicular skeleton. However, the systematical value of postcranial limbs is a matter of doubts in this case. The postcranial morphology suggests the ecological adaptations and locomotion strategy of the species and depends of the landscape character and the body weight (Sokolov *et al.* 1964; Gambaryan 1970; Sutula 1990) and, as it was already mentioned, has no any certain systematical significance. The studied fossil material includes complete skeletons or articulated parts of skeletons descovered in the Villafranchian and Postvillafranchian deposits of Italy. The postcranial remains of *D. eurygonos farnetensis* from Selvella are associated with the antlers and dentition (De Giuli 1986). The Selvella material allowed to separate the postcranial bones of *D. eurygonos* and *P. nestii* from Upper Valdarno and to associate them with antlers and skulls.

2. MORPHOLOGICAL DESCRIPTION

2.1 Pseudodama nestii

The antlers are rather thin and four-pointed, with basal and trez (middle) tines. The distal bifurcation formed by two tines of equal size, is oriented transversally to the sagittal plane (Azzaroli 1947). Pedicels are long and sloped backward from the face. The facial part of skull is long, however the praedental portion is relatively short. The cranial proportions (the long orbito-frontal part, the long facial portion) and some details of antler morphology (such as the frontally oriented distal fork) suggest this deer may be related to primitive modern and fossil deer of the *elaphus* group from the Western Mediterranean region, such as *Cervus aretinus*, *C. elaphus corsicanus*, *C. e. barbarus* and *C. e. hispanicus*. The lower praemolar series is comparatively long, the morphology of P_4 is primitive. The forelimb is characterised by a relatively short metacarpus, which is shorter than radius (the metacarpus/radius length ratio amounts to 92.5 %). The proximal end of the radius is comparatively wide. The lateral portion of articulation surface and the *epicondylus lateralis* are narrowed. In its turn, the medial portion of the proximal articulation surface is enlarged and the *epicondylus medialis* is prominent in the frontal view. The incision for articulation with *processus coronoideus* of ulna is comparatively deep. The distal portions of metapodial bones are sharply broadened, so the distal epiphyses has a triangular shape. The proximal phalanxes are very long and robust, while the medial phalanxes are relatively small.

2.2 Dama eurygonos

The four-pointed antlers generally are more robust and stronger bent sidewards if compared to *P. nestii*. The trez tine is comparatively small and occures only in fully grown mature individuals. The two terminal tines are very long and form the bifurcation oriented in a parasagittal plane. The general morphology of skull and dentition is similar to the modern fallow deer. The braincase is short and doumed, the orbito-frontal part is short, the pedicels are short and incranial. P_4 is molarised, the lower praedental series is short if compared with that of *P. nestii*. The nasal bones does not reach behind the line connecting the frontal edges of orbits, unlike modern *D. dama*. The proximal epiphysis of radius is narrowed if compared to one of *P. nestii*. The area of medial portion of the proximal articulation surface of radius is particularly diminished if compared to *P. nestii*, while the *epicondylus lateralis* is stronger. The incision for the articulation with *processus coronoideus* of ulna is shallow. The studied articulated forelimb is characterised by a comparatively long metacarpus, which is almost of the same length as the radius (the metacarpus/radius length index amounts to 98.6 %). The distal epiphysis of metacarpus is not broadened as sharp as in *P. nestii*. The metatarsal bone is long, its proximal epiphysis is narrow and deep. Proximal phalanxes are weak and very short if compared to *P. nestii*.

2.3 Dama eurygonos farnetensis

The deer under discussion is larger if compared to *D. e. eurygonos* from Upper Valdarno, its antlers are characterised by a very long curved first tine inserted at a certain distance from the burr. The antler beams are robust and strongly divergent, becoming horizontal in a section between the brow and the trez tine. Metapodials are relatively longer if compared to *D. eurygonos*. The ratio between length of metacarpus and radius (the mean value) amounts to 101.0 %.

2.4 Dama vallonnetensis

The antlers are very robust, however, they lack the trez (middle) tine, possessing only a very long and strong basal tine situated right above the burr and a distal bifurcation formed by two long tines oriented in the parasagittal plane. The skull morphology is typical for the genus *Dama*, however, unlike *D. dama*, the nasal bones does not reach behind the line connecting the anterior edges of orbits, the connection between nasal and praemaxillar bones is long. The praemaxillary bones are broadened and robust if compared to the modern fallow deer, the praedental portion is comparatively long. The relative metapodial length of *D. vallonnetensis* is similar to that of *D. eurygonos farnetensis*.

2.5 Dama clactoniana

D. clactoniana is a middle Pleistocene representative of the genus, characterised by the largest size and palmed antlers. Some interesting morphological peculiarities of this deer deserve to be mentioned here. The cranial material from Swanscombe (England) and Riano (Italy) display a morphology of facial bones, similar to the Villafranchian fallow deer such as the position of posterior edge of nasal bones and the long connection between praemaxillar and nasal bones. The facial morphology allows us to assume that *D. clactoniana* belongs to the same phyletical stock as the Villafranchian fallow deer. The complete articulated skeleton from Riano (Leonardi & Petronio 1976) is characterised by a very long distal part of limbs. The radius/metacarpus length ratio of the fallow deer from Riano amounts to 103.3 %.

3. MORPHO-FUNCTIONAL ANALYSIS

3.1 Comparison of P. nestii and D. eurygonos

The molarisation of praemolars and shortened praemolar series are two ways of adaptation to the tougher grass forage in ruminants (Vislobokova 1990; Spencer 1995). Both ways of adaptation increase the length of the grinding tooth surface. It may be achieved by the relative increasing of the molar grinding surface length that is followed by the praemolar length reducing, or the advanced molarisation of praemolars, which in this case work physiologicaly as molars. One can follow the both extreme variants of these morphological adaptations among Cervidae, for example, the very long praemolar series with highly molarised P_4 and P_3 in *Alces* and the very short and primitive praemolars in some Villafranchian *Eucladoceros*. The lower dentition of *D. eurygonos* shows a combination of molarised P_4 and the shortened praemolar row that may suggest the adaptation to a more or less coarse food. However, the *corpus mandibulae* remains shallow and slender, the fact suggesting that the species under consideration could not be a real grazer and may be classified as a mixed feeder.

The lower dentition of *P. nestii* maintains the primitive proportions with longer praemolar series and the simple morphology of praemolars. According to Spencer (1995), a long praemolar series is critical in processing dicotyledon material, because the praemolars, with their well-developed shearing crest, are used for slicing and puncture crushing of the soft juicy herbage. Among morphological characters of the so-called dicot feeders, Spencer (1995) mentioned the short predental portion of skull and narrow premaxillar bones. Unfortunately, the premaxillar bones in the single available complete skull of *P. nestii* from Figline are deformed, however, the remarkably short predental part of skull and relatively long lower praemolar series suggest this deer as a browser.

The ratio between limb segments in hoofed animals and their detailed postcranial morphology were used by many authors in study of the locomotion type and the landscape character (Egorov 1955; Sokolov *et al.* 1964; Gambaryan 1972; Sutula 1990; Köhler 1993). *D. eurygonos* has comparatively long metapodials and small and short phalanxes. The metapodial bones do not change their thickness distally much, unlike *P. nestii*. The articulation surfaces of distal metapotial epiphyses are high and narrow. The distal intertrochlear incision of metapodials is narrow. The enlisted characters are interpreted by Köhler (1993) and Sokolov *et al.* (1964) as the adaptation to open, flat and dry habitats.

P. nestii is characterised by short metapodials, conspicuously large proximal phalanxes and wide long bone epyphises. The possibility of correlation between the short metapotials and the short predental part of skull should be ruled out in this case, as the short predental portion in *P. nestii* is combined with relatively long face, and the reduced metapodial length is combined with long phalanxes. The distal epiphysis of metapodials are broadened sharply, the distal articulation surfaces are low if compared to *D. eurygonos*. The long radius and short metapodial bones are considered as adaptations to the saltatorial locomotion in wooded habitats (Gambaryan 1972; Sutula 1990). The short metapodial bones, the strongly broadened epiphyses of long bones are suggested as adaptations to wooded and mountainous landscapes (Egorov 1955; Köhler 1993).

The deep incision for *processus coronoideus* on the proximal epiphyses of radius observed in *P. nestii* apparently makes stronger the connection between radius and ulna and was suggested as an adaptation to the increased dynamic load upon the elbow joint (Croitor 1997). Gambaryan (1972) and Egorov (1955) reported the increased functional load upon elbow joint in ruminants adapted to mountainous habitats. One can suppose that the increased power load in the forelimbs in combination with short metapodials in *P. nestii* may suggest the adaptations to more or less mountainous landscape.

The large and very robust proximal phalanx and the strong middle phalanx with prominent plateau postarticulaire (Köhler 1993) suggest *P. nestii* as a typical woodland dweller. The phalanxes of *D. eurygonos* are much slender. The proximal phalanx is characterised by the deep incision of the proximal epiphysis for the articulation with metapodial verticulus. The middle phalanx has the comparatively weak plateau postarticulaire. Köhler (1993) regarded such a morphological pattern of phalanxes as the adaptation to open and dry habitats.

2.2 Evolutionary trends and ecology of the early Plestocene fallow deer

The evolutionary change in antler morphology of Villafranchian fallow deer concerns the reduction of trez tine and obviously should be interpreted in the context of the relationship between the social behavior and the antler shape. This tine is quite weak in *D. eurygonos* if compared to *P. nestii* and occurs only in fully-grown antlers of adult individuals. *D. vallonnetensis*, the descent of *D. eurygonos*, completely lost this tine and is characterized by the three-pointed antlers for a second time. One can assume that the trez tine in *D. eurygonos* has had the function of a hook fixing antlers of a rival in order to prevent the wounding during the males' combat. We can assume that the loss of the trez tine followed the change in rutting behavior of ancient fallow deer and, as a consequence, the change of the antler function. Perhaps, the simplified, but comparatively large antlers of *D. vallonnetensis* served mainly the function of social display and the antler function as an effective weapon was insignificant. The comparatively large size of antlers and their ritualised function may be interpreted as an adaptation of Villafranchian fallow deer to a more or less open landscape (Geist 1971, Köhler 1993). The long praedental part and broad praemaxillar bones of the fallow deer from Pirro Nord were regarded by Colucci (1993) as another adaptation to the coarce grass forage in the dry open landscape conditions.

The study of limb proportions revealed a gradual lengthening of the metapodial bones in the phyletical lineage *D.e. eurygonos – D.e. farnetensis – D. vallonnetensis – D. clactoniana*. The metacarpus has almost the same length as the radius in *D. eurygonos*, while in more advanced *D. eurygonos farnetensis* the metacarpal bone is longer than the radius. The relatively longest metapodial bones are recorded in the middle Pleistocene *D. clactoniana.* These changes in the limb proportion of fossil fallow deer are not correlated with the increased body size. Gambaryan (1972) reported a correlation between the larger body size and the short distal portions of appendicular skeleton. The study of individual variation of the modern *D. dama* revealed the similar correlation, as the smaller individuals (mainly females) has the longer metapodials. The limb proportions of the Villafranchian *Dama*, and particularly of the middle Pleistocene *D. clactoniana*, approach to those of the modern antilope *Gazella subgutturosa*, an open landscape inhabitant, which developed adaptations to cursorial locomotion in the conditions of open shrubland (Sokolov *et al.* 1964, Sutula 1990).

3. PALEOLANDSCAPE RECONSTRUCTION

The functional morphology study allows us to consider *P. nestii* as a forest dweller adapted to locomotion in the mountainous landscape. *D. eurygonos* displays adaptations typical of a cursorial runner and inhabited open landscape with woody vegetation. Both the deer species are important back-ground elements of the Tasso FU and suggest the mixed character of landscape with mountainous forests and more open and dry landscape of the savanna woodland type (according to the terminology of Cole 1963) in the lowlands. The evolutionary trends in antler morphology and limb proportions of ancient fallow deer indicate the gradual changes of the ecological conditions during the Farneta FU and the Pirro FU (terminal part of the late Villafranchian) toward the more open and dry type of savanna, the savanna parkland and tree-shrub savanna.

4. REFERENCES

Azzaroli, A. 1947. I cervi fossili della Toscana. *Paleontografia Italica* 18: 46-81.

Azzaroli, A. 1992. The cervid genus *Pseudodama n.g.* in the Villafranchian of Tuscany. *Paleontografia Italica* 79: 1-41.

Cole, M.M. 1963. Vegetation Nomenclature and Classification with Particular Reference to the Savannas. *S. Afr. Geogr. J.* 55: 3-14.

Colucci, A.P. 1993. *Pseudodama farnetensis* piccolo cervide del tardo *Villafranchiano proveniente dai riempimenti carsici dell'area fra Apricena e Poggio Imperiale (Fg)*. Thesis in Natural Sciences, University of Florence.

Croitor, R. 1997. Morpho-functional analysis of the elbow joint of fossil reindeer from Moldova (in Russian). *Pamiati Professora A.A. Braunera*: 165-168.

Croitor, R. In press. A revizion of Villafranchian small-sized deer from Upper Valdarno, Central Italy. *Paleontologia i Evolucio*.

De Giuli, C. 1986. Late Villafranchian Faunas in Italy: the Selvella Local Fauna in the southern Chiana Valley – Umbria. *Palaeontografia Italica* 74: 11-50.

De Giuli, C., Masini, F., Torre, D. 1986. The latest Villafranchian faunas in Italy: the Pirro Nord Fauna (Apricena, Gargano). *Palaeontografia Italica* 74: 56-62.

Di Stefano, G. & Petronio, C. 1998. Origin and relationships among *Dama*-like cervids in Europe. *N. Jb. Geol. Palaeont. Abh.* 207: 37-55.

Egorov, O.V. 1955. Ecology of Siberian Capricorn (*Capra sibirica* Meyer). (in Russian). *Transactions of the Zoological Institute* 17: 7-134.

Gambaryan, P.P. 1972. *The Running of Mammals. Adaptation features of locomotion organs* (in Russian). Leningrad.

Geist, V. 1971. The Relation of Social Evolution and Dispersal in Ungulates During the Pleistocene, with Emphasis on the Old World Deer and the Genus Bison. *Quaternary Research* 1: 283-315.

Köhler, M. 1993. Skeleton and Habitat of fossil and recent Ruminants. *Munchner geowiss. Abh. (A)* 25: 1-88. Munchen.

Leonardi, G. & Petronio, C. 1976. The fallow deer of European Pleistocene. *Geologica Romana* 15: 1-67.

Lumley de, H., Kahlke, H.-D., Moigne, A.-M., & Moulle, P.-E. 1988. Les faunes de grands mammiferes de la grotte du Vallonnet Roquebrune-Cap-Martin, Alpes-Maritimes. *L'Antropologie* 92 (2): 465-496.

Petronio, C. 1979. *Dama nestii eurygonos* Azz. di Capena (Roma). *Geologica Romana* 18: 105-125.

Pfeifer, Th. 1997. *Dama (Pseudodama) reichenaiui* (Kahlke 1996) (Artyodactyla:

Cervidae, Cervini) aus den Mosbach-Sanden (Wiesbaden-Biebrich). *Mainzer Naturwiss. Archiv* 35: 31-59.

Sokolov, I.I., Klebanova, E.A. & Sokolov, A.S. 1964. Morpho-functional peculiarities of locomotion apparatus of Saiga and Jeiran (in Russian). *Morphology of vertebrate animals. Transactions of the Zoological Institute* 33: 319-347.

Spencer, L. 1995. Morphological correlates of dietary resource partitioning in the African Bovidae. *Journal of Mammalogy* 76 (2): 448-471.

Sutula, V.A. 1990. Adaptation significance of proportions of the ungulates (in Russian). *Morphology of mammals and problems of locomotion. Transactions of the Zoological Institute* 215: 137-151.

Vislobokova, I.A. 1990. Fossil deer of Eurasia (in Russian). *Transactions of the Paleontological Institute* 240: 1-206.

Functional morphology and ecology of Villafranchian Proboscideans from Central Italy

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SUMMARY: The morpho-functional and ecological interpretation of the skeleton morphology of *Anancus arvernensis, Mammuthus meridionalis meridionalis* and *M. m. vestinus* from the Villafranchian of Central Italy is given in the present study. Unlike in hoofed animals, the locomotion strategy seems to have a minor influence upon the postcranial anatomy in the studied proboscideans. The body weight, the tusk weight and the optimal height at which tusks are used for gathering food, are regarded here as the important factors that influence the morphology and proportions of the studied proboscideans skeleton. According to this interpretation and taking into account the associated fauna, i) *A. arvernensis* is suggested as a ground-level feeder; ii) *M. m. meridionalis* is supposed as a woodland inhabitant with feeding habits similar to modern *Loxodonta africana* iii) *M. m. vestinus* is a highly specialized parkland-savanna species and a high-level feeder.

1. INTRODUCTION

The skeletal morphology and ecology of elephants is greatly influenced by their large size. Extant elephants posses a postcranial skeleton characterized by predominant graviportal adaptations, and feed upon a great variety of vegetal matter, depending on the season and the characteristics of the biome, to sustain their large body (Guy 1976). Nevertheless, comparisons of body proportions in several fossil proboscideans and in the two extant species, evidenced a number of differences that hint to diverse locomotory and feeding adaptations (Garutt 1954; Gambaryan 1974; Haynes 1990). The aim of this paper is to describe the skeletal anatomy of three Villafranchian (Middle Pliocene to Early Pleistocene) proboscideans from Central Italy and to reconstruct their habits, focusing on their dietary and habitat preferences.

We studied skeletal material, including either complete or partial skeletons, belonging to the tetralophodon gomphotherid *Anancus arvernensis* from Lower and Upper Valdarno (Tuscany) and to the elephantids *Mammuthus meridionalis meridionalis* from Upper Valdarno and *M. m. vestinus* from Farneta (Tuscany), Scoppito (Abruzzo) and Pietrafitta (Umbria). Comparisons were made with osteological material of Recent and fossil proboscideans, and with data taken from the literature.

2. MORPHO-FUNCTIONAL ANALYSIS

2.1 Description and Comparisons

2.1.1 Anancus arvernensis

No complete skulls of *Anancus* are known from Central Italy. However, two skulls from Villafranca d'Asti (Piedmont), kept at the paleontological museum of the University of Bologna, show that *A. arvernensis* is characterized by a rather elevated neurocranium, with a convex lateral profile (Fig. 1c). The alveolar portion of the premaxillary bones are short and anteriorly diverging. The tusks are very long, almost straight, and slender. The body is relatively long and wide. The neural spines of the anterior thoracic vertebrae form a well pronounced hump. Even though in the specimens at our disposal some of the neural spines are reconstructed, one can observe that the tallest neural spine forms the peak of the hump, and is situated close to the head. The limb bones are massive, with very short autopodials. The humerus is longer than the ulna: the ratio of humeral to ulnar physiological length is between 1.31 and 1.40 in the studied specimens. The humerus is very robust and is characterized by a well developed deltoid tuberosity. The olecranon of the ulna is very strong and long, being extended some-what toward the posterior (Fig. 2b). As in most proboscideans, the radius is smaller than the ulna. Nevertheless in *Anancus* the radius is relatively robust and its distal end is well developed. The ratio of ulnar to radial distal diaphysal width in the studied skeletons falls between 1.12 and 1.17. In the carpus, the lunar is extremely expanded transversely and articulates with the trapezoid.

2.1.2 Mammuthus meridionalis meridionalis

The skull of *M. m. meridionalis* has bulging parietals projected backwards (Fig. 1a). The neurocranium is high and pointed. The forehead is concave. The alveolar part of the premaxillaries is more developed than in *Anancus*. The tusks are shorter with respect to the skull length than in *Anancus*, and markedly thicker. They are directed downward and laterally at their exit from the sheaths and then upwardly and medially in their distal end. The body is taller and shorter than in *Anancus*. The cervical vertebrae are situated almost on the same axis as the thoracic segment of the back bone. In *M. m. meridionalis* the thoracic hump has not a

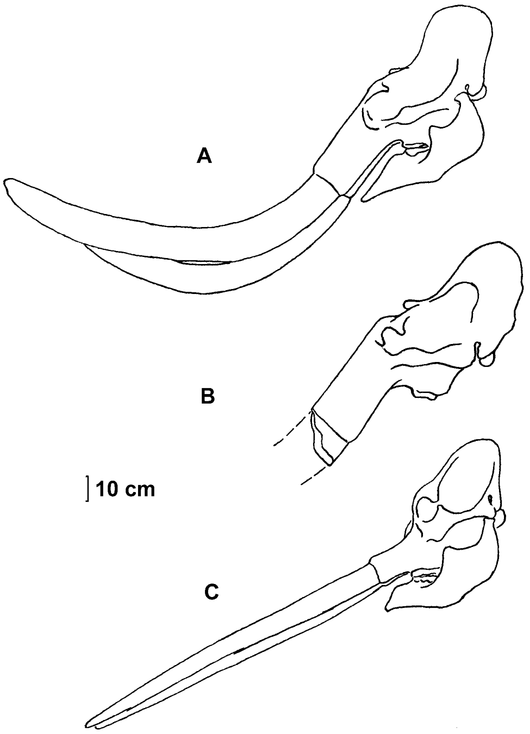

Fig.1 - Skull profiles of (A) *Mammuthus meridionalis meridionalis* (reconstruction), (B) *M. m. vestinus* (adapted from Azzaroli, 1977) and (C) *Anancus arvernensis* (reconstruction).

distinct peak, but it is somewhat more elevated caudally in comparison to *A. arvernensis*. No sexual dimorphism were evidenced with respect to this character. The proportion between forelimb segments is similar to that of *Anancus*, but *M. meridionalis* has relatively longer autopodials (Fig. 2a). The deltoid tuberosity of the humerus is less developed than in *Anancus*. The radius distal end is relatively smaller than in *Anancus*. The ulna to radius distal width ratio is 1.35. The lunar is consistently narrower and may either articulate with the trapezoid (aserial pattern) or not (serial pattern).

2.1.3 Mammuthus meridionalis vestinus

M. m. vestinus is characterized by a larger overall size (the shoulder height of the type specimen from Scoppito, is 3750 mm) if compared with *M. m. meridionalis* (the shoulder height of a male skeleton from Upper Valdarno is 3350 mm). The main differences with respect to *M. m. meridionalis* concern the morphology of the skull. *M. m. vestinus* is characterized by a shorter and deeper skull, with very long tusk sheaths (Fig. 1b). The neurocranium is higher and caudally displaced. The forehead is extremely concave. The tusks are larger, but similar in shape to that in *M. m.meridionalis*. The cervical section of the vertebral column is markedly dorsally flexed, even though this arrangement could be artificial. *M. m. vestinus* has slightly shorter limb distal segments, a condition possibly correlated with the larger body size. The observed differences in the limb proportions are, however, small if compared with the morphological divergence between modern *L. africana* and *E. maximus*.

2.2 Functional anatomy

The observed differences in skull morphology between *M. m. meridionalis* and *M. m. vestinus* can be related to the greater tusk weight of the latter subspecies. The lengthening and strengthening of the praemaxillary bones, and the concomitant shortening of the skull in *M. m. vestinus* give a strong support to the tusks and shifts the masse center of the “skull-tusks” system caudally (cf. Garutt 1954 and Maglio 1973). The tusk weight in *A. arvernensis* is significatively minor, so its biomechanical influence upon the morphology of the skull and the neck posture is limited. The very different tusk morphology between *M. meridionalis* and *Anancus* suggests a different use of this teeth in the two groups. In particular the three-dimentionally curved axis of *Mammuthus* tusks can be interpreted as an adaptation to lessen bending stresses (Khozatsky, 1990), which allows this teeth to reach a larger size, and possibly increases the variety of their use as tools. The upright position of the neck in *M. m. vestinus* may serve two functions: 1) shortening of the skull-neck lever system and 2) elevation of the head. This suggests a different posture and mobility of the head in the two *M. meridionalis* subspecies, possibly related to different feeding habits. In particular. *M. meridionalis vestinus* could be more specialized to a high-level feeding than *M. m. meridionalis*. The different shape of the lateral profile of the hump observed between *A. arvernensis* (the hump is peaked cranially) and both *M. meridionalis* subspecies (the posterior part of hump is elevated) may point out that the mastodon and the mammoths had basically different head posture and maneuverability, possibly in relation with tusk use. In particular they might have differed in the optimal height at which the tusks were used in gathering food.

The proportion between limb segments in terrestrial vertebrate was related to locomotion speed (Coombs 1978), to endurance (Hildebrand & Hurley 1985) or to feeding behavior (Garutt 1954). We observed in our sample that larger specimens posses a relatively longer humerus, which suggests also a possible allometric scaling effect. The lower humerus to ulna ratio of *Anancus*, with respect to *M. meridionalis*, could thus be explained by the smaller size of the former species. Anancus differentiates from the other two taxa by displaying a relatively larger radius distal end and a transversely more expanded lunar. According to Garutt (1954) the radius is relatively larger in such proboscideans (e.g.

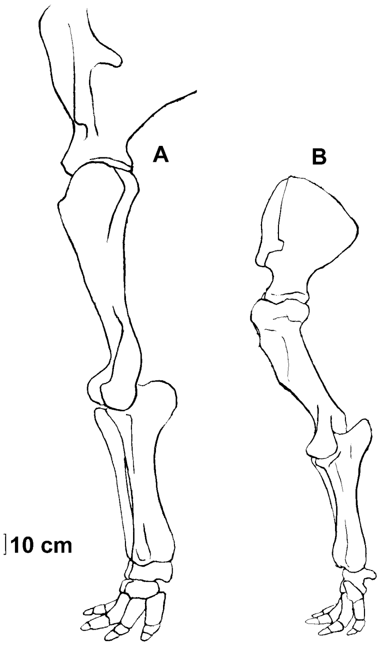

Fig.2 - Articulated forelimbs of (A) *M. m. meridionalis* and (B) *A. arvernensis*.

Moeritherium, Palaeomastodon), which are supposed to have fed on water vegetation and various underground parts of plants (rootstocks, root crops), and kept the forelimbs angled at the elbow joint while foraging. Such a position of the forelimbs supposes in fact an increased weight load upon the radius and, as a consequence, an increased dimension of this bone and of the carpals articulating with it (lunar). An additional functional load on the forelimbs occurred when the animal dig the soil in search of food using its tusks (Garutt 1954). The relatively enlarged radius and lunar, the strongly developed deltoid tuberosity, and the large and strong olecranon described in *A. arvernensis* suggest habitual flexion of the forelimbs in this species. This further supports the hypothesis that *A. arvernensis* was primarily a ground-level feeder. On the other hand, both serial and aserial carpal patterns were observed in the studied articulated skeletons of either *M. meridionalis* subspecies, so the functional importance of this character in these taxa is not supported by our observations.

3. ASSOCIATED FAUNAS AND PALAEOECOLOGY

Anancus occurs, in Central Italy, in Early (Triversa and Montopoli Faunal Units) to Middle (Costa S. Giacomo FU) Villafranchian localities. The interpretation of the Triversa mammal assemblage suggests a warm and humid climate and a forestal biotope (Gliozzi *et al.* 1997). In the younger Montopoli faunal assemblage, *Anancus arvernensis* is associated with *M.* cf. *gromovi* and *Equus liventzovensis.* The assemblage contains also small to large cervids and suggests a mixed habitat (forest and parkland), cooler than the Triversa episode. *A. arvernensis* appears to be a rather eurythermic species, but incapable to tolerate arid conditions. The interpretation of *Anancus* ecology, which is suggested here as a ground-level feeder, is problematic in the context of the faunal data reported above. One can suppose the species under consideration inhabited open landscapes or habitats near water bodies, however further study, that shall also consider dental adaptations, is needed to test this hypothesis.

M. meridionalis meridionalis is abundantly represented in Late Villafranchian (Olivola, Matassino-Poggio Rosso and Tasso local faumas) sediments from Tuscany, while *Anancus* is no more present or is extremely rare. The Late Villafranchian faunal assemblages are suggestive of a relative cool interval and a mixed, forest/parkland biotope (Gliozzi et al. 1997). In particular the functional analysis of the skeletal morphology of *Pseudodama nestii* and *Dama eurygonos* (see Croitor in this volume), which may be considered as the background elements of the Tasso fauna, suggests a landscape composed by forests, woodlands and, perhaps, more open savannahs. A palinological investigation of an Upper Valdarno sequence confirmed a cold and mainly dry episode in correspondence of the Matassino and Tasso faunas (Torre *et al.* 1996). *M. m. meridionalis* possibly occupied an ecological niche similar to that of modern *L. africana*, the food preferences of which depended on season (Guy 1976).

M. m. vestinus substitutes *M. m. meridionalis* in younger deposits from Central Italy, referred to the Farneta FU (Late Villafranchian). At Farneta, *M. m. vestinus* is associated with *D. eurygonos farnetensis*, *Equus stehlini, Leptobos* and *Castor plicidens* (Azzaroli 1977). Among these species, the advanced subspecies of Villafranchian fallow deer *D. eurygonos farnetensis* is represented by the highest number of remains. The morphological changes observed in the lineage *D. e. eurygonos – D. e. farnetensis* suggest a trend toward a more open, savannah-like habitat caused by cooling and aridisation of climate in Italy during the late Villafranchian (see Croitor in this volume). The occurrence in the Farneta assemblage of *M. m. vestinus*, that we interpreted as a specialized high-level feeder, suggests in particular, a savannah parkland (according to classifications of Cole 1963, and Reed 1998) with tall trees, shrubs and grasses. The rich fauna from Pietrafitta contains abundant remains of *M.m.vestinus* and records the first occurrence of *Praemegaceros obscurus* (Gliozzi *et al.* 1997). The occurrence of the giant deer at Pietrafitta indicate the presence of open areas and a relatively cold climate. The presence of permanent water bodies and of forested areas is on the other hand testified by the lignite deposits were the fauna was found, and by the occurrence of *Castor plicidens* in the assemblage. *M.m .vestinus* appears to have inhabited savannah parkland (according to classifications of Cole 1963, and Reed 1998) with tall trees, shrubs and grasses.

4. REFERENCES

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

Cole, M.M. 1963. Vegetation Nomenclature and Classification with Particular Reference to the Savannas. *S. Afr. Geogr. J.* 55: 3-14.

Coombs, W.P. 1978. Theoretical aspects of cursorial adaptations in dinosaurs. *Quart. Rev. Biol.* 53: 393-418.

Gambaryan, P.P. 1974. *How mammals run.* New York: Wiley.

Garutt, V.E. 1954. *Archidiskodon meridionalis* (Nesti) from Pliocene of the North Coast od Azov Sea (in Russian). *Trans. Comm. Quat. res*. 10 (2): 3-76. Moscow-Leningrad.

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 in Italy. The state of the art. *Riv. It. Paleont. Stratigr.* 10 (3): 369-388.

Guthrie, D. 1990. *Frozen Fauna of the Mammoth Steppe*. Chicago: Univ. Chicago Press.

Guy, P.R. 1976. The feeding behavior of elephants (*Loxodonta africana*) in the Sengwa Area, Rhodesia. *S. Afr. J. Wildlife res*. 6: 55-63.

Haynes, G. 1990. *Mammoths, mastodonts, and elephants*. Cambridge University Press.

Hildebrand, M., Hurley, J. 1985. Energy of the oscillating legs of a fast-moving cheetah, pronghorn, jackrabbit, and elephant. *J. Morph.* 184: 23-31.

Khozatsky, L.I. 1990. Biomechanic significance of some structural peculiarities of the tusks in proboscideans (in Russian). *Trans. Zool. Inst.* 212: 65-71.

Maglio, V.J. 1973. Origin and Evolution of the Elephantidae. *Trans. Amer. Philos. Soc.*, n. series, 63(3): 1-149.

Reed, K.E. 1998. Using large mammal communities to examine ecological and taxonomic structure and predict vegetation in extant and extinct assemblages. *Paleobiol.* 24 (3): 384-408.

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

History of Quaternary Proboscideans of the South of Western Siberia inferred from dental system analysis

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SUMMARY: Detailed history of mammoth lineage development — from ancient archidiskodonts to the latest mammoths — was reconstructed for the South of Western Siberia. Vast material from the Kuznetsk Basin characterizing rather detailed stratigraphic sequence of the Quaternary was studied using an original method of molar analysis of the author. Multidimensional diagrams show diversity of dental phenotypes in the framework of evolutionally directional selection during all the lineage development. Most of them compose successions in thick- and thin-enamel zones of distribution. Morphofunctional differences between these forms, as well as complex of other data, are indicative of chronological and paleoecological nature of dental system changes of proboscideans. It was found that the tendencies of group development in this region (as well as in Eurasia as a whole) were determined by adaptations to periodic changes of periglacial and interglacial environments.

1. INTRODUCTION

Paleontological material from the Kuznetsk basin occurs in sediments that make almost continuous sections from the beginning of Lower Pleistocene to Holocene (Foronova 1999). The fossils allowed to reconstruct a sequence of both glacial and periglacial faunas and to compare it with climatic-stratigraphic horizons of West-Siberian scheme. Proboscideans are represented on this territory by a majority of well-known forms, as well as by a number of first recorded ones belonging to genera *Archidiskodon* and *Mammuthus*. Collection contains crania fragments, mandibles, over 500 molars.

2. METHOD

Systematic identification of elephants is commonly established by morphological composition characters of last molars. Traditionally, average plate frequency on 100 mm stretch, plate length and enamel thickness are regarded as the most informative features. We do not consider number of plates as a definitive feature because of two reasons: 1) it is inconvenient for statistical procedures (complete molars are few and they substantially reduce sample); 2) it was found that there were no sequential (form by form) increase of number of plates in a crown, as it was previously thought. Maximal plate number (29-30) is typical of very large mammoths that existed in the final stage of Riss (seconds half of Zaale, about 160 ka) but not of the latest *Mammuthus primigenius*. Material was studied using authors' method for analysis of mentioned features, building and analyzing of multidimensional diagrams (Foronova & Zudin 1986; 1999; 2001) that allowed to retrieve new information on the lineage history. To finally define a taxonomical range of forms established using this information one needs to make a revision of the entire group. Currently, preliminary description of material is substantially complicated by restrictions of present nomenclature.

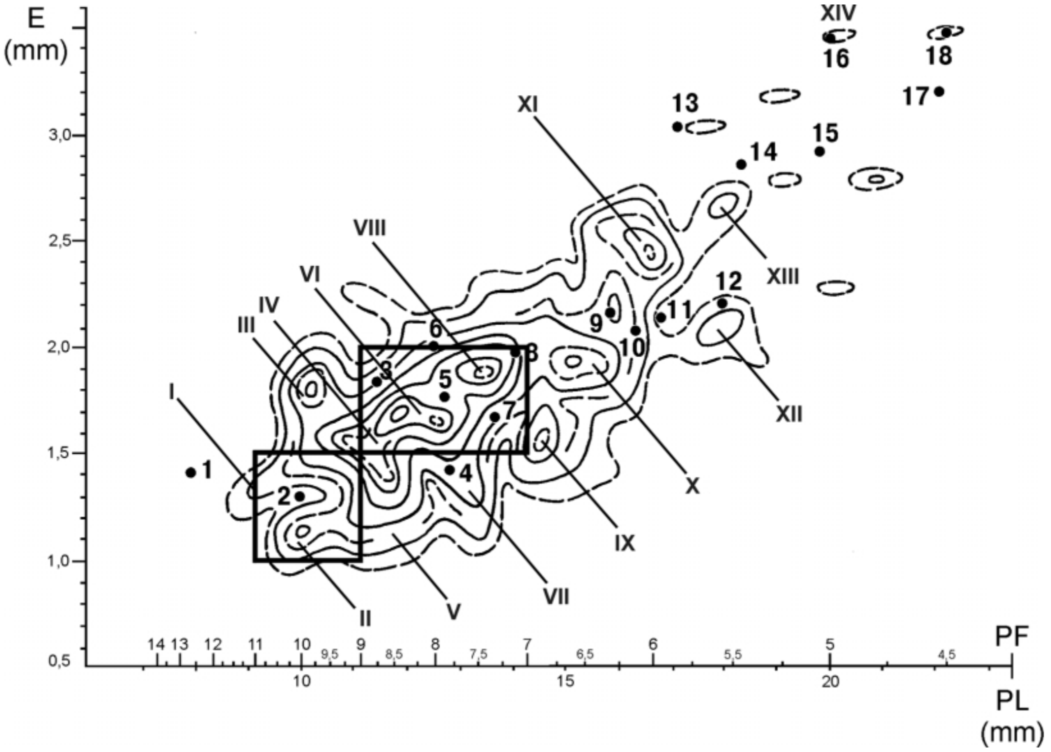


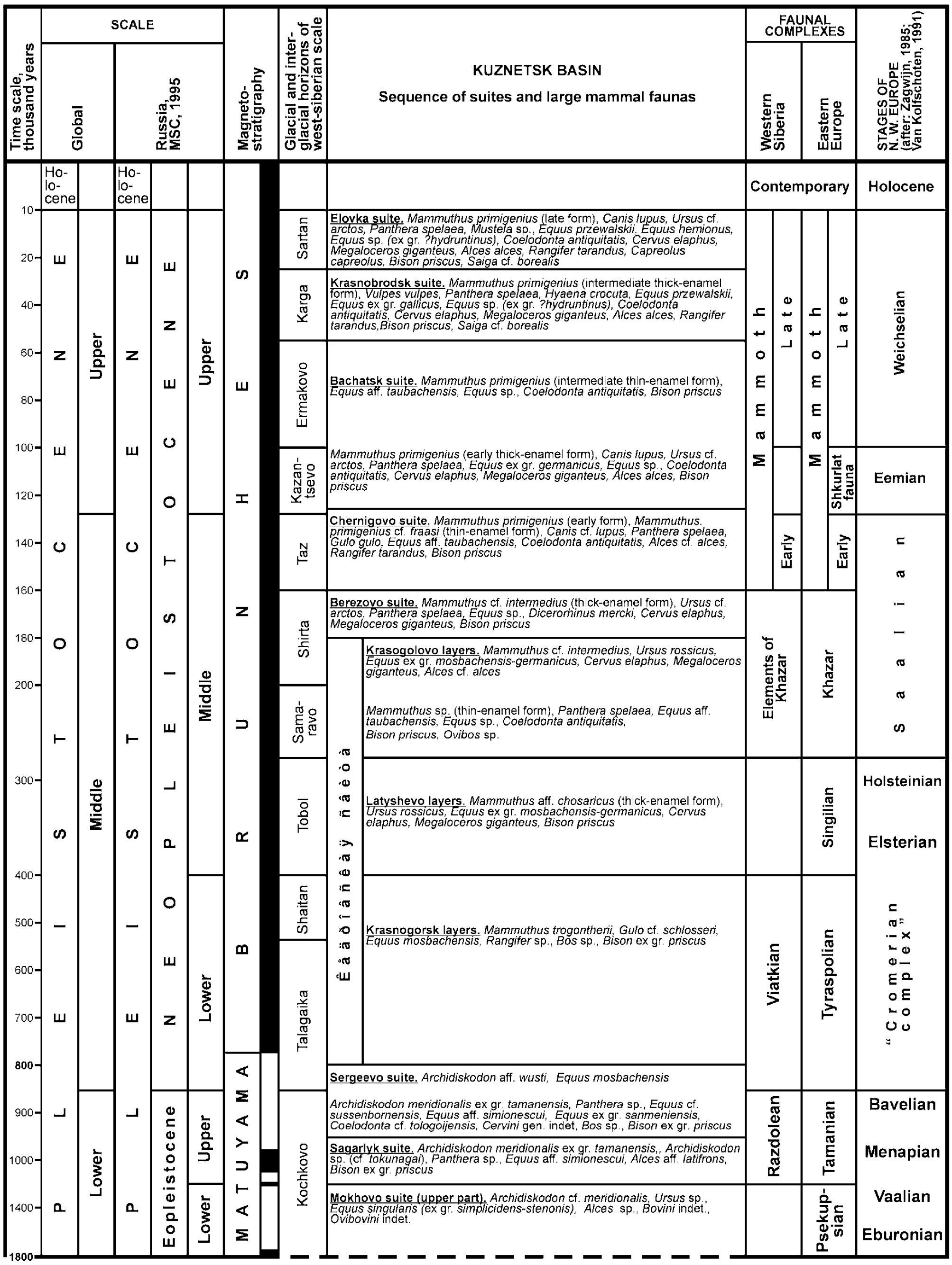
Fig.1 - Variability of elephants of the mammoth lineage, after the material from Kuznetsk Basin (Southeast of Western Siberia)

Coordinate axis: E — enamel thickness; PF — plate frequency on 100 mm; PL — plate length.

Rectangles show variability limits for features of early and late form of *Mammuthus primigenius* Blum. (according to Vangengeim E.A., 1961).

Points show coordinates of type specimens of taxa established before or assumed (see Fig. 1, Foronova & Zudin, this volume).

Adaptive peaks (forms): I, II - *Mammuthus primigenius* (late form); III, IV - *M. primigenius* (intermediate thick-enamel form); V — *M. primigenius* (intermediate thin-enamel form); VI — *M. primigenius* (early form); VII — *M. primigenius* cf. *fraasi*; VIII — *M.* cf. *intermedius*; IX — *Mammuthus* sp.; X — *M.* aff. *chosaricus*; XI — *M. trogontherii*; XII — *Archidiskodon* aff. *wusti*; XIII — *A. meridionalis* ex gr. *tamanensis*; XIV — *A.* cf. *meridionalis*.



Elovka suite. *Mammuthus primigenius* (late form), *Canis lupus, Ursus* cf. *arctos, Panthera spelaea, Mustela* sp., *Equus przewalskii, Equus hemionus, Equus* sp. (ex gr. *?hydruntinus), Coelodonta antiquitatis, Cervus elaphus, Megaloceros giganteus, Alces alces, Rangifer tarandus, Capreolus capreolus, Bison priscus, Saiga* cf. *borealis*

Krasnobrodsk suite. *Mammuthus primigenius* (intermediate thick-enamel form), *Vulpes vulpes, Panthera spelaea, Hyaena crocuta, Equus przewalskii, Equus* ex gr. *gallicus, Equus* sp. (ex gr. *?hydruntinus), Coelodonta antiquitatis, Cervus elaphus, Megaloceros giganteus, Alces alces, Rangifer tarandus,Bison priscus, Saiga* cf. *borealis*

Bachatsk suite. *Mammuthus primigenius* (intermediate thin-enamel form), *Equus* aff. *taubachensis, Equus* sp., *Coelodonta antiquitatis, Bison priscus*

Mammuthus primigenius (early thick-enamel form), *Canis lupus, Ursus* cf. *arctos, Panthera spelaea, Equus* ex gr. *germanicus, Equus* sp., *Coelodonta antiquitatis, Cervus elaphus, Megaloceros giganteus, Alces alces, Bison priscus*

Chernigovo suite. *Mammuthus primigenius* (early form), *Mammuthus. primigenius* cf. *fraasi* (thin-enamel form), *Canis* cf. *lupus, Panthera spelaea, Gulo gulo, Equus* aff. *taubachensis, Coelodonta antiquitatis, Alces* cf. *alces, Rangifer tarandus, Bison priscus*

Berezovo suite. *Mammuthus* cf. *intermedius* (thick-enamel form), *Ursus* cf. *arctos, Panthera spelaea, Equus* sp., *Dicerorhinus mercki, Cervus elaphus, Megaloceros giganteus, Bison priscus*

Krasogolovo layers. *Mammuthus* cf. *intermedius, Ursus rossicus, Equus* ex gr. *mosbachensis-germanicus, Cervus elaphus, Megaloceros giganteus, Alces* cf. *alces*

Mammuthus sp. (thin-enamel form), *Panthera spelaea, Equus* aff. *taubachensis, Equus* sp., *Coelodonta antiquitatis, Bison priscus, Ovibos* sp.

Latyshevo layers. *Mammuthus* aff. *chosaricus* (thick-enamel form), *Ursus rossicus, Equus* ex gr. *mosbachensis-germanicus, Cervus elaphus, Megaloceros giganteus, Bison priscus*

Krasnogorsk layers. *Mammuthus trogontherii, Gulo* cf. *schlosseri, Equus mosbachensis, Rangifer* sp., *Bos* sp., *Bison* ex gr. *priscus*

Sergeevo suite. *Archidiskodon* aff. *wusti, Equus mosbachensis*

Archidiskodon meridionalis ex gr. *tamanensis, Panthera* sp., *Equus* cf. *sussenbornensis, Equus* aff. *simionescui, Equus* ex gr. *sanmeniensis, Coelodonta* cf. *tologoijensis, Cervini* gen. indet, *Bos* sp., *Bison* ex gr. *priscus*

Sagarlyk suite. *Archidiskodon meridionalis* ex gr. *tamanensis,, Archidiskodon* sp. (cf. *tokunagai*), *Panthera* sp., *Equus* aff. *simionescui, Alces* aff. *latifrons, Bison* ex gr. *priscus*

Mokhovo suite (upper part). *Archidiskodon* cf. *meridionalis, Ursus* sp., *Equus singularis* (ex gr. *simplicidens-stenonis), Alces* sp., *Bovini* indet., *Ovibovini* indet.

Fig.2 - Biostratigraphy of Quaternary sediments in the Kuznetsk Basin.

3. MAIN RESULTS

The most ancient proboscideans on the South-East of Western Siberia were found in reverse-magnetized sediments of Lower Pleistocene (Lower Eopleistocene in the Russian Scale). In plate frequency and enamel thickness they are similar with typical *Archidiskodon meridionalis* (Nesti) (Fig. 1, adaptive peak (a.p.) XIV). These morphological characteristics, as well as information on accompanying forms, permit to correspond this fauna with Late Villafranchian fauna of Italy (Sardella *et. al.* 1998). However, Siberian *A.* cf. *A. meridionalis* has a number of peculiar features: high hypsodonty of a crown, absence of medial sinus on a plate, close positioning of plates. These differences were probably caused by climatic conditions differing from of conditions of Southern elephant's habitat in Europe. A form similar to progressive *A. meridionalis* ex gr. *tamanensis* (= *cromerensis* - *voigtstedtensis*) (Fig. 1, a.p. XIII) existed here in the second part of Early Pleistocene (in the beginning of Late Eopleistocene in Russia or in the end of Late Villafranchian / beginning of Galerian in Italy (Sardella *et al.* 1998).

Considerable climatic and environmental changes in the end of Early and especially in the beginning of Middle Pleistocene (Lower Eopleistocene of Russian Scale, Foronova 1998) have conditioned further development of mammoth lineage. Periodic changes of landscape and vegetation have caused an increase of plate number and frequency in a crown, and decrease of plate length and enamel thickness. Obtained diagrams show these changes to be successive stages of elephants' adaptation to periodic environmental changes. Successions (rows) of ecologically different thick- and thin-enamel forms can be distinctly traced in the lineage from the beginning of Middle Pleistocene.

Most advanced form of genus *Archidiskodon* existed in the Kuznetsk Basin in the fauna of the beginning of Early Neopleistocene (Russian scale) analogous to Early Cromerian faunas in Europe, in the end of Matuyama epoch. On the diagram it can be seen as first well-pronounced thin-enamel group (Fig. 1, a.p. XII). These elephants are similar to late *A. meridionalis* in average plate frequency, but differ from them by significantly low enamel thickness. According to our data (Foronova & Zudin 1999), it is this form, being on the boundary between two genera, that could have been a transition from archidiskodonts to mammoth and could have given a new direction for the lineage development. *Mammuthus trogontherii*, having an enamel somewhat thicker than with this form lectotype (Fig. 1, a.p. XI), was a main element in the fauna of Early Neopleistocene (analogous to Tyraspolian fauna of Southern Europe and faunas of major part of Cromerian and Elsterian of Western Europe) (Fig. 2).

Many paleontologists strove to find transitional forms in the mammoth lineage. These studies however were complicated by a serious obstacle — overlap of features of closely related forms. Our diagrams could help to partially resolveclarify this problem.

A number of transitional forms (well-pronounced adaptive peaks) between *M. trogontherii* and *M. primigenius* s.l. can be seen on all regional diagrams (including the one for Kuznetsk Basin) in the major part of Middle Neopleistocene (Tobol, Samarovo, and Shirta horizons of West-Siberian Scale = Holstenian and major part of Saalian of Western Europe) *M.* aff. *chosaricus* (Fig. 1, a.p. X) with a relatively thick enamel is typical of Tobol interglacial. Very large thin-enamel *Mammuthus* sp. (Fig. 1, a.p. IX) corresponds to Samarovo glaciation item. Due to some of its features it can be established as a separate taxon. A peculiar thick-enamel *M.* cf. *intermedius* (Fig. 1, a.p. VIII) with a habitat covering entire Europe and Western Siberia could exist during Shirta (within Saalian) warming.

According to traditional concepts, further lineage development must have matched the parameter limits determined by E.A. Vangengeim (1961) for "early" and "late" forms of *M. primigenius*. It was found, however, that in the end of Middle and Late

Pleistocene there was maximal variability in the lineage (Foronova & Zudin 1989, 1999). Series of thick- and thin-enamel forms (Fig.1) going far beyond the parameter limits can be distinguished within the vast and still conventionally used species of *M. primigenius*. They are characterised by different morphofunctional adaptations caused by climatic changes.

Mammoth with thick-enamel phenotype (Fig. 1, a.p.: VI, III, IV) occurred on the South of Western Siberia in interglacial Kazantsevo (Eemian) and Karga (inside Weichselian) epochs. It is remarkable that the later form (Fig.1, a.p. III) looks more distinct on the diagram. Its correspondence with mentioned period is confirmed by a number of ^{14}C-dates: from 45220 +/-1700 to 28870 +/-60. These mammoth are known throughout the Eurasia.

Mammoth with narrow band-like plates and thin low-folded enamel (Fig. 1, a.p. VII, V) were predominant in periglacial faunas, in Tazov (Late Saalian) and Early Zyriansk (Early Weichselian) epochs. Remarkable is the form *M. primigenius* cf. *fraasi* (Fig. 1, a.p. VII) whose plate composition was the most typical for the teeth of thin-enamel phenotype and the most adjusted for functions of cutting and grating. In the final stage of lineage development corresponding to the time of Sartan glaciation mammoths had maximal number of plates and the thinnest enamel. This stage corresponds to parameters of Taimyr mammoth defined as a neotype for species *M. primigenius* Blum. Nevertheless, even on this stage the diagram shows two adaptive peaks — conventionally thick-enamel and thin-enamel ones (Fig.1, a.p.: I, II), the first being more advanced in plate frequency. No more progressive forms were not found in the Western Siberia, while one more form — the last one from the thick-enamel succession (Fig. 1, point 1) with maximal plate frequency (14 on 100 mm) — was established in Europe and Eastern Siberia (Foronova & Zudin 1986; 2001).

4. CONCLUSION

An assumption about autochthonous speciation in mammoth lineage within the entire station (Foronova & Zudin 1999) is confirmed on the example of stratified material from the Kuznetsk Basin — the largest stratigraphic region on the South of Western Siberia. Comparison of the diagram with analogous schemes made for different regions of Northern Eurasia shows general similarity of lineage structure and presence of the majority of adaptive peaks (forms), analogous by their position in the structure. Some mismatch in their parameters on the diagrams for Europe, Western and Eastern Siberia is indicative of geographical clinal variability caused by various response of regional environments to global climatic changes. Results obtained with the help of the method provide new information on development of Quaternary proboscideans and give an opportunity for morphofunctional diagnostics of periglacial and interglacial forms which in turn may be used in climatic stratigraphy and paleoecological reconstructions.

5. REFERENCES

Foronova, I.V. 1999. Quaternary Mammals and Stratigraphy of Kuznetsk Basin (Southwestern Siberia). *Antropozoikum “Quaternary of Siberia”* 23: 71-97.

Foronova, I.V. & Zudin, A.N. 1986. A new approach to the study of North Eurasian fossil elephants of the *Archidiskodon-Mammuthus* lineage. In Arkhipov, S.A. (ed.), *Biostratigraphy and Paleoclimates of Pleistocene in Siberia*: 6-31. Novosibirsk. (In Russian).

Foronova, I.V. & Zudin, A.N. 1999. The structure of the lineage *Archidiskodon-Mammuthus* in Eurasia and peculiarities of its evolution. In Haynes, G., Klimovicz, J. & Reumer, J.W.F. (eds.), *Mammoths and the Mammoth Fauna: Studies of Extinct Ecosystem — Deinsea* 6: 103-118.

Foronova, I.V. & Zudin, A.N. 2001. Discreteness of evolution and variability in Mammoths lineage: method for group study. *This volume*.

Sardella R., Abbazi L., Argenti P., Azzaroli A., Caloi L., Capasso Barbato L., Di Stefano G., Ficcarelli G., Gliozzi E., Kotsakis T., Masini F., Mazza P., Mezzabotta C., Palombo M.R., Petronio C., Rook L., Sala B. & Torre D. 1998. Mammal fauna turnover in Italy from the Middle Pliocene to the Holocene. *Medelingen Nederlands Inst. Toegepaste Geowetenschappen TNO*, 60: 499-512, Haarlem.

Vangengeim, E.A. 1961. *Paleontological foundation of anthropogene stratiigraphy of Northern Asia*. Moscow: Nauka.

Remains of fossil elephants in Poland

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SUMMARY: Beside of some mastodont remains known since the beginning of the 19th century from the present territory of Poland, more than 400 localities of finds of *Elephantidae* are known so far. The remains have been collected during the 19th and 20th centuries. Most of the sites occur along the main rivers of Poland Vistula and Odra, as well as around the scientific centres like Gdańsk, Warszawa, Kraków, Poznaƒ, Wrocław. Skulls, partially preserved skeletons and mainly single teeth and bones belong to three species of fossil elephants: *Palaeoloxodon antiquus, Mammuthus trogontherii* and *Mammuthus primigenius.*

1. EARLIEST RECORDS OF PROBOSCIDEANS FROM POLAND

1.1 Proboscideans

The first notes about finds of proboscideans in Poland are known from the 19th century. Pusch (1836) wrote about bones of mastodons “which were not yet exactly determined” found near Warszawa at the Vistula river, in the Carpathian Mts, and in the vicinity of Kraków. However, there is probably a mistake in the determination of those finds which already mentioned Kowalski (1959).

1.2 Mastodonts

Perhaps remains of Elephantidae have been described as teeth and bones of mastodons. Later authors were already more precisely in their descriptions and examined the material with greater care. In those earliest publications it has been shown that in the recent territory of Poland remains of mastodons occur only in five localities, i.e. the surroundings of Toruń, Oborniki, Opole, Przeworno (Kubiak 1975) and Bełchatów (Kowalski & Kubiak 1993).

1.3 Elephants

Finds of fossil elephants are mentioned in the literature since the 19th century for instance Hauer (1851). That find was a well preserved mammoth skull examined and described over one hundred years later (Kulczycki 1955; Kubiak 1980). Several papers were published at the end of the 19th and at the beginning of the 20th centuries dealing with elephant finds from Silesia.

2. FOSSIL ELEPHANTS OF POLAND

Since the beginning of the 20th century papers dealing with finds of elephant remains have been published in Poland. A summary of those finds, with special attention to South Poland has been published in the sixtieth (Kubiak 1965). In this paper are also cited positions of former publications. Among four species of fossil elephants known from the Pleistocene of Europe three of them are known, so far, from the territory of recent Poland.

Those are: *Palaeoloxodon antiquus, Mammuthus trogontherii* and *Mammuthus primigenius*.

2.1 Palaeoloxodon antiquus (Falconer & Cautley 1847)

This species is known from only few localities of Poland (Kowalski 1959; Kubiak 1965, Ruprecht 1971). The most important finds of the forest elephant in Poland are three almost completely preserved skeletons found in the Upper Pleistocene deposits (Eemian interglacial) in Warsaw, in Jóżwin near Konin, and in the vicinity of Ciechanów (Jakubowski 1996).

2.2 *Mammuthus trogontherii* (Pohlig, 1888)

The steppe elephant has been found in Poland, so far, in a dozen localities in Central and South Poland only (Kowalski 1959; Kubiak 1965). Because of the difficulties in the exact determination of remains of this species, it is possible that a part of those remains has been described as belonging to the woolly mammoth (Kubiak 1989). Remains of the elephant from Rzochów, described by Borsuk-Białynicka *et al.* (1969) as *Mammuthus trogontherii* belong after Środoń (1976) and Kubiak (1989) actually to *Mammuthus primigenius*.

2.3 Mammuthus primigenius (Blumenbach, 1799)

The woolly mammoth is one of the most common species of Pleistocene mammals in Poland. Hundreds of localities are known. Unfortunately in most of them the stratigraphy is unknown. The finds consist mainly of single bones and molar teeth. Well preserved parts of skeletons and skulls are found very seldom. Two skulls are especially interesting. These are the mammoth skulls from Dębica and Bzianka near Rzeszów. Both are described by Kubiak (1980). The skull from Dębica was not damaged at all. The skull from Bzianka was also well preserved. It has strange characteristics : small dimensions, slender, strongly twisted tusks with downward pointed tig and the adult age of this animal. Another find of special interest is the site Spadzista Street B in Kraków, where remains of about 70 mammoths could be discovered (Kozłowski & Kubiak 1972; Kubiak *et al.* 1974; Wojtal 1996).

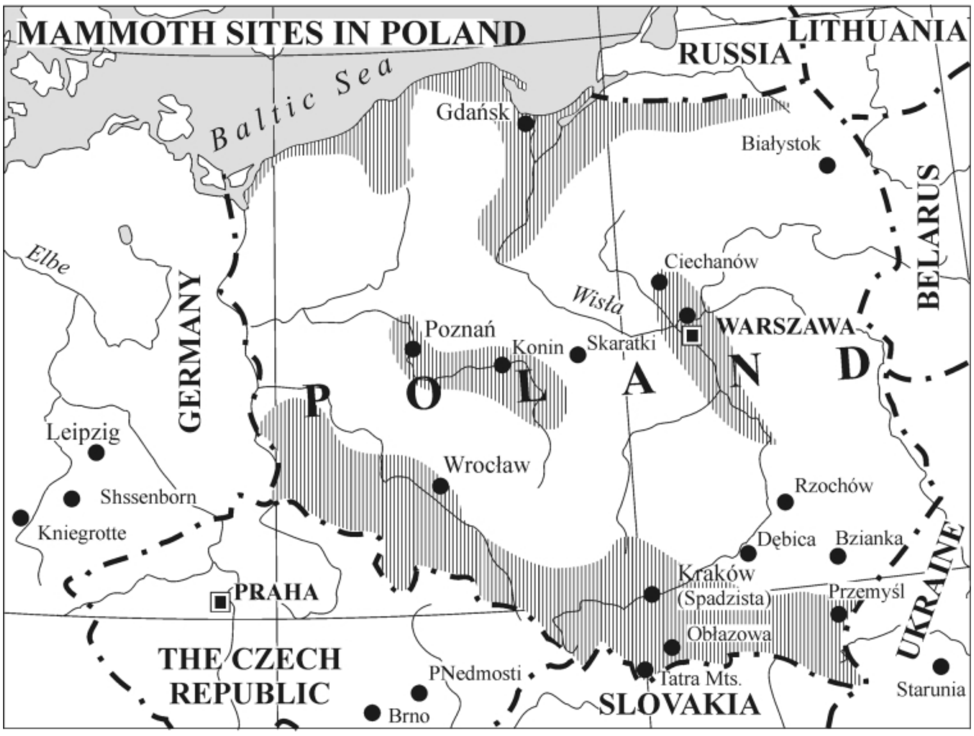

Fig.1 - Distribution of fossil elephant finds (screen) and localisation of main sites.

Tab.1 - List of species and main localities.

Species	Localities	Remains	References
Palaeoloxodon antiqus			
	Warsaw	skeleton	Jakubowski 1996
	Jóżwin/Konin	skeleton	Jakubowski 1996
	Ciechanów	skeleton	Jakubowski 1996
	Sokółka/Białystok	molars	Ruprecht 1971
	Tatra Mts.	ridge plate	Kubiak 1965
Mammuthus trogontherii			
	Rzochów	skeleton	Borsuk-Białynicka et al. 1965
	South Poland:		
	Łańcut	molars	Kubiak 1965
	Jarosław	molars	Kubiak 1965
	Przemy´l	molars	Kubiak 1965
Mammuthus primigenius			
	Skaratki	complete manus	Chmielewski et al. 1962
	Bzianka	skull	Kubiak 1980
	Dębica	skull	Kubiak 1980
	Kraków/Spadzista	bone structures kill site?	Kozłowski et al. 1972 Kubiak et al. 1974 Wojtal 1996
	Obłazowa	ivory boomerang	Valde-Nowak et al. 1987

3. RADIOCARBON DATINGS

Only few radiocarbon datings of mammoth finds from Poland are known. The above mentioned skulls: from Dębica = 25,300 y. BP, the skull from Bzianka comes from a mammoth living 14,080 y. BP Other radiocarbon datings of mammoth finds from Poland show the site Skaratki - more than 37,000 years BC. (Chmielewski & Kubiak 1962), and Cracow-Spadzista-Street B - 21,000 years BP. According to the above cited datings the mammoth finds of Poland derive from a phase about 40,000 to 14,000 years. That means the mammoths from Poland lived during the Middle Vistulian interglacial complex until the Late vistulian time.

4. REFERENCES

Borsuk-Białynicka, M. & Wysoczański-Minkowicz T. 1969. Mammuthus trogontherii from Rzochów. *Bull. Acad. Pol. Sc., Ser. Géol. et Géogr.*, 17: 143-147.

Chmielewski, W. & Kubiak, H. 1962. The find of mammoth bones at Skaratki in the Łowicz district. *Folia Quaternaria* 9: 1-29.

Hauer, F.V. 1851. Fossiler Elephantenschädel von Bzianka bei Rzeszów. *Jb. Geol. Reichsanstalt* 2: 158-159.

Jakubowski, G. 1996. Forest elephant *Palaeoloxodon antiquus* (Falconer & Cautley, 1847) from Poland. *Prace Muzeum Ziemi* 43: 85-109.

Kowalski, K. 1959. *Katalog ssaków plejstocenu Polski (A Catalogue of the Pleistocene Mammals of Poland)*. PWN Warszawa-Wroclaw.

Kowalski, K. & Kubiak, H. 1993. *Gomphotherium angustidens* (Cuvier, 1806) /Proboscidea, Mammalia/ from the Miocene of Belchatów and the Proboscidean Datum in Poland. *Acta Zool. Cracov*. 36/2: 275-280.

Kozłowski, J.K. & Kubiak, H. 1972. Late Palaeolithic Dwellings made of Mammoth Bones in South Poland. *Nature* 237 (No 5356): 463-464.

Kubiak, H. 1965. Slonie kopalne Polski poludniowej. (The Fossil Elephants of South Poland - English summary). *Folia Quaternaria* 19: 1-43.

Kubiak, H. 1975. *Gomphotherium angustidens* (Cuvier, 1806) /Proboscidea, Mammalia/ from the Miocene of Przeworno (Silesia, Poland). *Acta Zool. Cracov*. 20: 469-480.

Kubiak, H. 1980. The Skulls of *Mammuthus primigenius* (Blumenbach) from Dębica and Bzianka near Rzeszów, South Poland. Folia Quaternaria 51: 31-45.

Kubiak, H. 1989. Trabowce - Proboscidea. In K. Kowalski (ed.), Historia i ewolucja lad-owej fauny Polski (History and Evolution of the Terrestrial Fauna of Poland). *Folia Quaternaria* 59-60: 203-208.

Kubiak, H. & Zakrzewska, G. 1974. Fossil mammals. In Upper Palaeolithic Site with Dwellings of Mammoth Bones - Cracow, Spadzista Street B. *Folia Quaternaria* 44: 77-95.

Kulczycki, J. 1955. Les ossements des mammouths. *Palaeont. pol.* 7: 1-65.

Pusch, G.G. 1836. *Geognostische Beschreibung von Polen sowie der übrigen Nordkarpathen-Länder.* Stuttgart u. Tübingen: J.G. Cotta.

Ruprecht, A.L. 1971. Słof lény (*Palaeoloxodon antiquus*) w pólnocno-wschodniej Polsce (The Forest Elephant /*Palaeoloxodon antiquus*/ in S-E Poland. *Folia Quaternaria* 37: 19-21.

Środoń, A. 1976. Late-Pleistocene Flora and Mammoth Skeleton from Rzochów near Mielec (S.Poland). *Biul. Periglac*. Łódż 26: 299-309.

Valde-Nowak, P., Nadachowski, A. & Wolsan, M. 1987. Upper Palaeolithic boomerang made of a mammoth tusk in south Poland. *Nature* 329: 436-438.

Wojtal, P. 1996. The Cracow Spadzista Street (B) Upper Paleolithic Site. *Current Research in the Pleistocene* 13: 73-75.

Contributions to the study of the Neogene representatives of Ordo Proboscidea (Mammalia) from Eastern Europe

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SUMMARY: In recent years, remains of various proboscideans were collected from paleontological deposits. The stratigraphic position of these deposits is more definite now. The proposed biostratigraphical scheme (Table) is the result of field and bibliographical research on Neogene Proboscideans from Eastern Europe.

Within the Neogene fauna from Eastern Europe, the fossil remains of diverse forms of proboscideans are known. These proboscideans can be referred to the following families: *Gomphotheriidae, Mastodontiidae, Deinotheriidae* and *Elephantiidae*. Many questions concerning phylogeny, ecology, appearance time and stratigraphical spreading of different forms of Ordo Proboscidea from the Orient Paratethys regions are disputable till present.

At the beginning of Bessarabian, within the land fauna from Eastern Europe, the following forms of proboscideans were present: *Gomphotherium angustidens* Cuvier, *Platybelodon sp.*, *Deinotherium bavaricum* Meyer. These forms, probably, also existed in the fauna of Volhonian (upper Astaracian MN 8 biozone). Within the Hipparion fauna they can be considered as relic forms of the Anchitherium fauna.

Some proboscideans, such as *Tetralophodon longirostris* Kaup, *Zygolophodon turicensis* Schinz, *Deinotherium giganteum* Kaup, existed parallel with the forms mentioned in the fauna of early Vallesian from Bessarabian (MN 9 biozone). They were also widely spread in the Hipparion fauna of Turolian type.

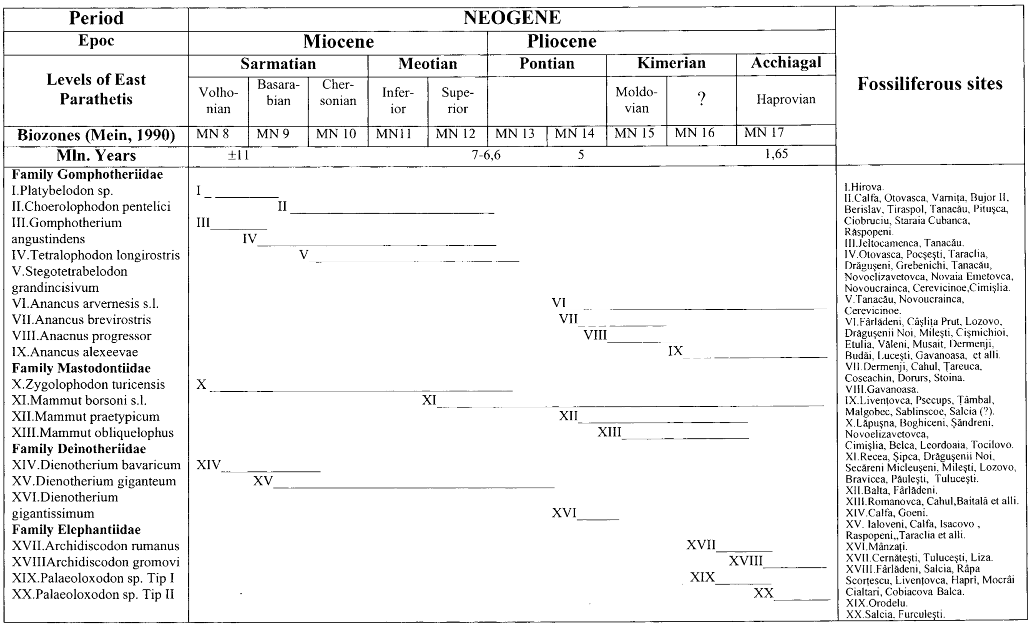
Zygolophodon turicensis Schinz is also known from Central Europe in the fauna of Astaracian. In Meotsian, *Z. turicensis* Schinz is met within the land fauna with *Mammut borsoni* Hays. Both species belong to the same phylogenetic branch. At the beginning of Pontsian, *Z. turicensis* Shinz disappears, but *M. borsoni* Hays survives until upper Pliocene (MN 16 biozone).

One of the characteristic elements of the Hipparion fauna is *Tetralophodon longirostris* Kaup. This form from the fauna of early Vallesian (MN 9 biozone), in comparison with the forms of this species in the Hipparion fauna of Turolian type, is characterized by some archaic morphological features which bring it near to *Gomphotherium angustidens* Cuvier. It can be viewed as *G. angustidens-longirostris* intermediate form. At the beginning of Vallesian in some regions *G. angustidens* is met together with *T. longirostris*.

It is possible that *Stegotetrabelodon grandincisivum* Schlesinger descended from *T. longirostris* Kaup in Meotsian. Both *T. longirostris* Kaup and *S. grandincisivum* Schlesinger disappeared at the beginning of Pontsian. In Meotsian, they are met together.

In the Hipparion fauna from Eastern Europe *Choerolophodon pentelici* Gaudry et Laertet was widely spread. It appears at the beginning of Vallesian (MN 9 biozone) together with the first representatives of *Hipparion* genus.

Tab.1 - Ordo *Proboscidea* (Mammalia) in the Neogene of Eastern Europe:a biostratigraphical scheme.



Period	NEOGENE										Fossiliferous sites
Epoc	Miocene					Pliocene					
Levels of East Parathetis	Sarmatian			Meotian		Pontian		Kimerian		Acchiagal	
	Volhonian	Basarabian	Chersonian	Inferior	Superior			Moldovian	?	Haprovian	
Biozones (Mein, 1990)	MN 8	MN 9	MN 10	MN11	MN 12	MN 13	MN 14	MN 15	MN 16	MN 17	
Mln. Years	±11				7-6,6		5			1,65	

Taxon	Fossiliferous sites
Family Gomphotheriidae	
I.Platybelodon sp.	I.Hirova.
II.Choerolophodon pentelici	II.Calfa, Otovasca, Varniţa, Bujor II, Berislav, Tiraspol, Tanacău, Pituşca, Ciobruciu, Staraia Cubanca, Răspopeni.
III.Gomphotherium angustindens	III.Jeltocamenca, Tanacău.
IV.Tetralophodon longirostris	IV.Otovasca, Pocşeşti, Taraclia, Drăguşeni, Grebenichi, Tanacău, Novoelizavetovca, Novaia Emetovca, Novoucrainca, Cerevicinoe,Cimişlia.
V.Stegotetrabelodon grandincisivum	V.Tanacău, Novoucrainca, Cerevicinoe.
VI.Anancus arvernesis s.l.	VI.Fârlădeni, Câşliţa Prut, Lozovo, Drăguşenii Noi, Mileşti, Cişmichioi, Etulia, Văleni, Musait, Dermenji, Budăi, Luceşti, Gavanoasa, et alli.
VII.Anancus brevirostris	VII.Dermenji, Cahul, Ţareuca, Coseachin, Dorurs, Stoina.
VIII.Anacnus progressor	VIII.Gavanoasa.
IX.Anancus alexeevae	IX.Livenţovca, Psecups, Ţâmbal, Malgobec, Sablinscoe, Salcia (?).
Family Mastodontiidae	
X.Zygolophodon turicensis	X.Lăpuşna, Boghiceni, Şăndreni, Novoelizavetovca, Cimişlia, Belca, Leordoaia, Tocilovo.
XI.Mammut borsoni s.l.	XI.Recea, Şipca, Drăguşenii Noi, Secăreni Micleuşeni, Mileşti, Lozovo, Bravicea, Păuleşti, Tuluceşti.
XII.Mammut praetypicum	XII.Balta, Fârlădeni.
XIII.Mammut obliquelophus	XIII.Romanovca, Cahul,Baitalâ et alli.
Family Deinotheriidae	
XIV.Dienotherium bavaricum	XIV.Calfa, Goeni.
XV.Dienotherium giganteum	XV. Ialoveni, Calfa, Isacovo , Raspopeni,,Taraclia et alli.
XVI.Dienotherium gigantissimum	XVI.Mânzaţi.
Family Elephantiidae	
XVII.Archidiscodon rumanus	XVII.Cernăteşti, Tuluceşti, Liza.
XVIIIArchidiscodon gromovi	XVIII.Fârlădeni, Salcia, Râpa Scorţescu, Livenţovca, Haprî, Mocrâi Cialtari, Cobiacova Balca.
XIX.Palaeoloxodon sp. Tip I	XIX.Orodelu.
XX.Palaeoloxodon sp. Tip II	XX.Salcia, Furculeşti.

This form, possibly, migrated from Southern Europe and Anterior Asia. In these regions it is also met within the fauna of upper Astaracian.

At present, it is possible to distinguish an archaic form of *Choerolophodon pentelici* Gaudry et Lartet, which is characteristic of the fauna of early Vallesian, and more progressive, more specialized one, which is met in the fauna of Meotsian.

In the fauna of early Vallesian, D*einotherium giganteum* Kaup is met together with *D. bavaricum* Meyer.

The representative of the genus *Platybelodon* recently descovered in the settlement Hirova, Republic of Moldova (paleomagnethical determermed age is about 11 mln.) is the relictive form of the *Anchitherius* fauna (Lungu, Obada, 2001 a, b).

At the end of Bessarabian (MN 9 biozone), in the fauna of early Vallesian disappear the following forms: *Platybelodon* sp., *Deinotherium bavaricum* Meyer, *Gomphotherium angustidens* Cuvier. This event was, probably, bound up with the change of landscape-climatic conditions in Eastern Europe.

T*etralophodon longirostiris* Kaup, *Choerolophodon pentelici* Gaudry et Lartet, *D. giganteum* Kaup were characteristic of the fauna of late Vallesian (MN 10 biozone) within Chersonian. It is to be mentioned that *D. giganteum* Kaup reaches gigantic sizes similar with those of *D. gigantissimum* Stefanescu is a synonym of *D. giganteum* Kaup.

In the fauna of Meotsian, next to the mentioned forms, appear the following new forms of proboscideans: *M. borsoni* Hays, *S. grandincisivum* Schlesinger, which prove to be much more sopecialized.

The validity of *Mammut praetypicum* and *M. obliquelophus* is a particular problem.

At the Meotsian-Pontsian boundary in Eastern Europe takes place the change of landsacape-climatic conditions, which caused disappearing *T. longirostris* Kaup, *S. grandincisivum* Schlesinger, *Z. turicensis* Schinz, *Ch. pentelici* Gaudry et Lartet in the land fauna and appearing some new forms.

As for the Elephantidae family the validity of *Archidiskodon rumanus* Stefanesco species, the most ancient elephant in Europe, was successfully confirmed and it emphasized the necessity of spotlighting a neotype and a stratotype for

"Scortselian" faunistic complex. The validity of *A. gromovi* Garutt et Alexeeva was confirmed, and two archaic types of forest elephants – *Palaeoloxodon* sp. type I (for MN 16 biozone) and *Palaeoloxodon* sp. type II (for MN 17-18 biozones) – were made evident.

In recent years, diverse forms of proboscideans were collected from the deposits of land fauna. The stratigrgraphic position of these deposits is more definite now. These facts are the basis of concretizing in the fauna of proboscideans from Eastern Europe.

The proposed biostratigraphical scheme (Tab. 1) is an analysis result of field and bibliographical research on Neogene Proboscideans from Eastern Europe. The bibliographical sources used in the research are quoted here.

REFERENCES

Belyaeva, E.I. 1948. Catalog mestonakhozhdeniy tretichnykh nazemnych mlecopitayushikh na territorii SSSR. *Trudy Paleontol. In-ta AN SSSR* 15(3): 114. [In Russian].

Dubrovo, I.A. & Kapelist, K.V. 1973. *Catalog mestonakhozhdenii tretichnykh pozvonochnykh USSR*: Moskva: Nauka. [In Russian].

Kubiak, H. 1972. The Skull of *Mammut praltypicum* (Prohosciodea, Mammalia) from the Zagielloian University of Cracow, Poland. *Acta Zool.Cracoviensia* 13: 305-324.

Lungu, A. & Cemartan, G. 1989. K istorii razvitiya gipparionovoy fauny pozdnego sarmata severnykh oblastey continental'nogo obramleniya Vostochnogo Paratetisa. *Trudy Gosud. Craevedch. muzeya* 3: 48-66. [In Russian].

Lungu, A. & Obada, Th. 1998. Proboscideele faunei Neogene de pe teritoriul Republicii Moldova. *Facultatea de Geografie la 60 de ani. Dezvoltarea geografiei in Republica Moldova*: Kishinau.

Lungu A. & Obada,Th., 2001a. Discovery of *Platybelodon* Borissiak, 1928 (Proboscidea, Mammalia) a representative genus in the territory of the Republic of Moldova. *An.Ins. Geol. Rom.* 72, Suppl. 28-29.

Lungu A., Obada, Th., 2001b. New data on Early Vallesian fauna from Moldova. *Analele Università ii de Stat din Republica Moldova. Seria "Chimico-biologice"*: 51-55.

Mein, P. 1990. Updating of MN zones., In Lindsay, E.H., Fahlbusch, V. & Mein, P. (eds.), *European Neogene mammal Chronology*: 73-90. New York: Plenum Press.

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On the presence of *Elephas recki* at the Oldowan prehistoric site of Fejej FJ-1 (Ethiopia)

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SUMMARY: Fejej FJ-1 site, located in the lake Turkana basin, in southern Ethiopia, is an Oldowan prehistoric site. Its deposits yielded an abundant large mammal fauna associated with hominid remains. A tuff, which can be correlated to the KBS Tuff of the Koobi Fora Formation (1,88 My) or to the H-1 Tuff of the Shungura Formation (1,9 My) caps the archaeological level (unit III). The faunal association of Fejej FJ-1 can be correlated to member G (2,32 to 1,9 My) of the Shungura Formation. Below the hominid bearing level we can recognise a badland (unit I) where dental elements assigned to *Elephas recki* have been discovered. They are similar to the sub-species *E. recki atavus*, characterised by an increase of hypsodonty possibly related to an opening of the environment, which have been described by Michel Beden (1987) in the upper part of F and member G of Shungura Formation (Omo Valley).

1. INTRODUCTION

The Oldowan prehistoric site Fejej FJ-1 (Asfaw *et al.* 1991), located in the lake Turkana basin in southern Ethiopia, consists in a hill formed by fluvial deposits and capped by a tuff (Lumley *et al.* in prep.) (Bahain *et al.* 2000).

This tuff (Unit IV), which can be correlated to the KBS Tuff of the Koobi Fora Formation (1.88 Ma) or to the H-1 Tuff of the Shungura Formation of the Lower Omo Valley (1.9 Ma), overlies a fluvial fine-grained sequence in which the archaeological level (unit III) is intercalated. The archaeological level has yielded large mammals remains, hominid bones and an abundant oldowan lithic assemblage.

Below the hominid bearing level, fluvial large grained deposits individualise the “badland” (unit I).

Fossil remains come both from the archaeological level and surface collections.

Surface collections concern :
- The “badland”, also named unit I, which consists of the base of the sequence
- Unit III, located beneath the tuff
- Unit V, overlaying the tuff

The archaeological level (unit III) provides large mammal bones, mainly assigned to *Aepyceros shungurae*, and showing tool marks. Two anatomical connections have been discovered during the excavation. Fragments of non blunt *Elephas recki* molar plates were also found. Unit I provides deciduous teeth, molar fragments and a split tusk of *Elephas recki*. Another Elephantidae, *Deinotherium*, is also represented by jugal teeth fragments.

2. CHRONOLOGY AND BIOSTRATIGRAPHY

The tuff (unit IV) was correlated on tephrochronological basis with the KBS Tuff of the Koobi Fora Formation (1.88 Ma) (Asfaw *et al.* 1991). Or to the H-1 Tuff of the Shungura Formation (1.90 Ma) (Haileab and Feibel 1993). Sediments of the units III and IV display a normal magnetic polarity, which allows to

Fig.1 - Posterior part of the second right upper molar FJ1 BL-SF291 of *Elephas recki* cf. *atavus* from Fejej 1.

place the sedimentation during the Olduvai subchron event (1.96-1.76 Ma) (Bahain *et al.* 2000). Finally, a RPE date of the archaeological layer resulted in an age of 1.9 +/- 0.32 Ma (Bahain *et al.* 2000).

The association, in unit V, of the two suids *Notochoerus scotti* and *Metridiocherus modestus*, according to Tim D. White (1995) chronological data, allows to situate the age of the site between 1.8 Ma (last *N. scotti* upon KBS Tuff) and 1.89 Ma (first *M. modestus* below KBS Tuff). *M. modestus* is also encountered in unit III. These data indicate that an age around 1.9 My can be suggested for unit III.

The rodents from the archaeological level, represented by *Arvicanthis* morphotype *niloticus/primaevus* and *Heterocephalus* cf. *atikoi*, also support this dating.

The biostratigraphical data don’t show the difference between the “badland” and unit III. But the data show the correlation between those units and member G (2.32 to 1.9 Ma) of Shungura Formation in the Lower Omo Valley (Moullé *et al.* in prep.).

3. DESCRIPTION OF *ELEPHAS RECKI* DENTAL ELEMENTS

Fejej FJ1 *Elephas recki* remains have been studied in accordance with the synthesis carried out by Michel Beden (1987) concerning Shungura Formation in Omo valley.

“Badland” provided two second lower deciduous teeth and a fragment of third one. A fragment of the posterior part of a molar showing three plates non really blunt is probably a right first upper molar.

An exploration of a limited area where some fragments of molar plates were outcropping shows two posterior molar parts which can be related to two upper molars belonging to the same individual. An isolated tusk is perhaps connected to those dental elements. These teeth are blunt with an altered occlusal surface which can not allow to observe precisely the enamel loop.

The second upper right molar shows, four posterior plates and the posterior face of a plate where the tooth is broken. Estimated maximal width of the fragment is about 70 mm. Maximal width of the teeth must have been more significant. Plate frequency is about 5 plates each 10 cm on this fragment, which do not represent the whole medial part of the complete tooth. Enamel loop thickness is about 3 mm.

The second upper left molar shows posterior platelet, two posterior plates and the posterior

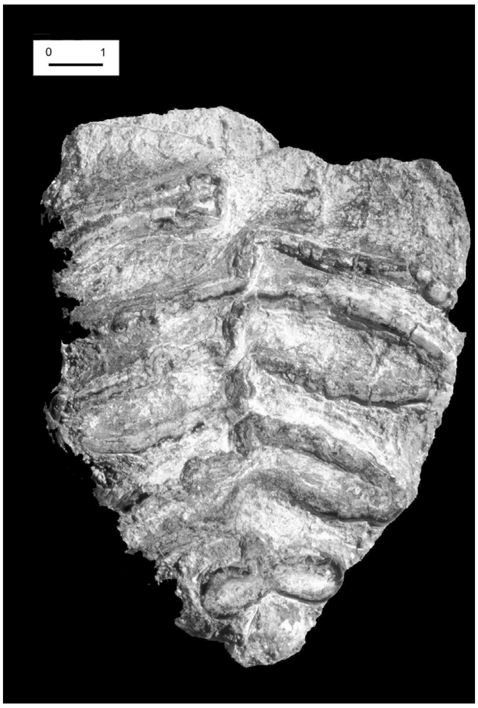

Fig.2 - Posterior part of second left upper molar FJ1 BL-SF292 of *Elephas recki* cf. *atavus* from Fejej 1.

side of a plate where the tooth is broken. Enamel loop thickness is about 3 mm.

“Badland” provided also two blunt molar fragments, which can correspond to posterior parts of second upper molars.

The second right upper molar (FJ1 BL-SF292) (Fig. 1) shows, three posterior plates and lingual fragment of plate IV (where the tooth is broken). The anterior side of plate III has lost its enamel loop on labial side because of tooth wear. Just as, on the lingual side, the enamel loops of the anterior side of plate III and the posterior side of plate IV form an islet. The plate patterns are tight at their centres; and the medial pillar is badly individualised. The enamel loop thickness ranges from 3 to 4 mm.

The second left upper molar (FJ1 BL 292) (Fig. 2) shows, two posterior plates and posterior half of plate III. General pattern is similar to the second upper molar Omo 75-1969-3054 (inferior G member of the Shungura Formation) of *Elephas recki atavus* described by Michel Beden and stored in Ethiopian National Museum in Addis Ababa. The plates show clearly the individualised small medial pillars. The enamel loop thickness ranges from 3 to 4 mm.

The significant molar wear may explain the great enamel loop thickness observed on some areas.

The two fragments of second upper molars show enamel folds, as far as plate side (3 or 4 folds can be observed in every 10 cm). Fold amplitude is equivalent to enamel thickness, which corresponds to value 2 according to Michel Beden’s methodology. The general appearance of enamel loop fold is equal to classical pattern of *Elephas recki atavus* Arambourg, 1947 plates described by Beden (1987, p. 152).

According to Beden (1987), *Elephas* dental remains from upper part of F and G members of the Shungura Formation, assigned to *Elephas recki atavus*, show a great variability. Nevertheless, the molars are characterised by an increase of hypsodonty, size, plate frequency and enamel fold amplitude. Thus, *Elephas recki atavus* is more evolved than the sub-species *Elephas recki shungurensis* Beden, 1980 which is present from member C to lower part of member F of the Shungura Formation.

4. CONCLUSION

Despite their scarcity and their fragmentary nature, *Elephas recki* remains from Fejej FJ-1 unit I (badland) are similar to sub-species *Elephas recki atavus*, which have been described by Beden (1987) in F superior and G member of the Shungura Formation (Lower Omo Valley). The evolution of *Elephas recki atavus*, whose molars are characterised by an increase of hypsodonty, can be related to an opening of the environment.

5. REFERENCES

Asfaw, B., Beyene, Y., Semaw, S., Suwa, G., White, T. & Woldegabriel, G. 1991. Fejej: a new paleoanthropological research area in Ethiopia. *Journal of Human Evolution* 21: 137-143.

Bahain, J.J., Barsky, D., Beyene, Y., Byrne, L., Desclaux, E., Echassoux, A., Laurent, M., Lumley, H. de, Lumley, M.A. de, Marchal, F., Moullé, P.E., Pleurdeau, D. & Valensi, P. 2000. Le site de Fejej FJ-1, sud Omo, Ethiopie. Cadre géochronologique et biostratigraphique, paléoenvironnement, l'Homme et l'industrie. Poster présenté au colloque "Les Hominidés et leurs environnements: Histoire et Interactions". Maison des Sciences de l'Homme et de la Société, Poitiers 18-20 Septembre 2000.

Beden, M. 1987. Les Eléphantidés (*Mammalia, Proboscidae*). In Coppens, Y. & Howell, F.C. (eds.), *Les faunes plio-pléistocènes de la basse vallée de l'Omo (Ethiopie).* 2. Editions du CNRS.

Lumley, H. de, Beyene, Y., Bahain, J.J., Barsky, D., Darmon, F., Desclaux, E., Echassoux, A., Laurent, M. & Moullé, P.E. (in preparation). Cadre biostratigraphique, paléoécologique, culturel et géochronologique du site FJ-1 à Fejej (Ethiopie). *L'Anthropologie.*

Moullé, P.E., Echassoux, A., Alemseged, Z. & Desclaux, E. (in preparation). Les faunes plio-pléistocènes du site FJ-1 à Fejej (Ethiopie). *L'Anthropologie.*

White, T.D. 1995. African Omnivores: Global Climatic Change and Plio-Pleistocene Hominids and Suids. In Vrba, E.S., Denton, G.H., Partridge, T.C., Burckle, L.H. (eds.), *Paleoclimate and Evolution, with Emphasis on Human Origins*. Yale University Press.

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Elasmotherians - evolution, distribution and ecology

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SUMMARY: Elasmotherians from an Early Pleistocene, Tamanian mammal assemblage at Sinaya Balka (Black Sea area, Russia) were studied in order to (1) assess the evolution and distribution of this genus, and (2) evaluate the likelihood that *Elasmotherium caucasicum* is a bona fide species. In this region, *Elasmotherium caucasicum* Borissjak, 1914, is commonly associated to the Tamanian elephant (*Archidiskodon meridionalis tamanensis*). It has a more primitive dental morphology than *E. sibiricum* Fisher, 1808, with which it was formerly considered to be synonymous, and therefore constitutes a separate species. Ecological peculiarities and paleoenvironmental conditions, proposed for *E. caucasicum*, could be useful for understanding the biogeography of the region at the time of *Archidiskodon meridionalis tamanensis.*

1. INTRODUCTION

Elasmotheriums are giant rhinoceroses which lived in the Early Pleistocene of Southern Russia. After the Tamanian elephant (*Archidiskodon meridionalis tamanensis*), *Elasmotherium caucasicum* is the most frequently found mammal in the Tamanian assemblage. They form the most typical assamblage of large herbivores for the interval 1.1-0.8 My. This assemblage is found in Sinaya Balka and Tsymbal localities. Moreover, *Elasmotherium* is known from Akhtanisovskaya and Fontalovskaya localities and Archidiskodon from Kuchuguri locality (Fig. 1).

2. DISCUSSION

A new genus and species, *Elasmotherium sibiricum*, was established by Fisher von Valdgeim (1808). A second species, *E. caucasicum* was distinguished by A. Borissjak (1914) on the basis of its large and morphologically-distinct teeth from Sinaya Balka. *E. caucasicum* was considered to have more primitive “rhinoceros-like” teeth morphology, due to presence of the postfossette basin on the upper teeth. The validity of this species, however, was subsequently challenged by V.A. Terjaev (1948), who equated it with *E. sibiricum* on the grounds that the presence of the postfossette basin is typical for slightly worn teeth only.

Two more species, which represent the earliest record of the genus, were described from China by Chow (1959): *E. inexpectatum* and *E. peii* (Shansi). Chinese species were considered by Chow (1959) to be ancestral for *E. caucasicum* and *E. sibiricum*, which were widely distributed in the Eastern Europe (e.g., Russia), there being only two questionable records of *Elasmotherium* sp. thus far recorded in western Europe (Shvireva 1995).

Investigation of new material from an Early Pleistocene Tamanian mammal assemblage at Sinaya Balka, near the Black Sea, shows that *E. caucasicum* differs from *E. sibiricum* by its relatively longer teeth-row and P4, bigger teeth, and an s-shaped metaconid. It is likely that *E.caucasicum* is ancestral to *E. sibiricum* as it retains some primitive dental features, notably (1) a postfossette basin on the upper teeth, (2) a less sinuous enamel layer of the external wall of ectoloph, (3) irregular fold of the enamel (the peaks of the fold have the different height).

The genus *Elasmotherium* appeared in Central Asia during the Late Pliocene. Its origin appears to be connected to the genus *Sinotherium* (Upper Miocene – Lower Pliocene), although certain species of *Sinotherium*, which could be ancestral to *Elasmotherium*, is unknown. *E. inexpectatum* and *E. peii* inhabited Eastern China during the

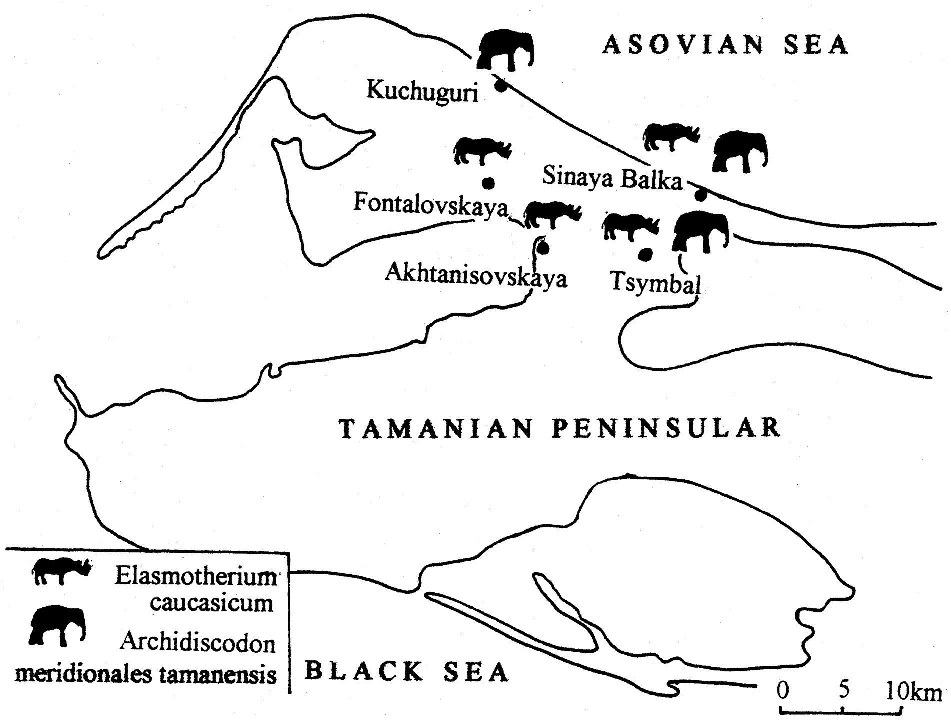

Fig.1 - The distribution with the localities of Tamanian mammal assemblages.

Upper Pliocene - Lower Pleistocene. They disappeared c. 1.6 Ma ago (Qui & Qui 1995). The earliest records of *Elasmotherium* sp. in Russia are known from the Upper Pliocene assemblages near the Black Sea. This area evidently became a second center of their radiation. This suggests that *Elasmotherium* sp. may have developed separately in Russia and China.

E. caucasicum was widely distributed in this area 1.1 Ma and 0.8 Ma. The more advanced *E. sibiricum* appeared in the Middle Pleistocene. It occupied all of the southwestern part of Russia, reaching eastward to western Siberia. Elasmotherians persisted in the eastern Europe untill the end of the Middle Pleistocene. The records of elasmotherians in the western Europe, however, is problematic, thus the western limit of their migration remains to be documented.

Morphological peculiarities of elasmotherians have generated two main hypotheses concerning their appearance and the character of their habitat. The first, most widely accepted view portrays them as large wooley animals with a large forehead horn that thrived on an open steppe. The other view, proposed by V.A. Terjaev (1948), assigned elasmotherians to riparian biotopes.

Our work indicates that elasmotherians dwelt in both riparian and steppe biotopes. The riparian biotope is suggested by dental and skull morphology. The combination of such characters as the absence of canines and strongly developed lateral processes of the atlas implies lateral movements of the head, presumably for grasping grass. The hypsodont dentition indicates presence of mineral grains in the food. Such food could be obtained by pulling out dense plants from the moist soil. These conditions are typical for riparian biotopes. On the other hand, a steppe biotope is indicated by their rather long and slender limbs, which would have served well for creatures grazing over vast areas. Thus, the available data suggest that the habitats of elasmotherians could haveincluded both riparian biotopes and the adjacent high grass steppe. Given that elasmotherians coexisted with *Archidiskodon*, the same ecological conditions can be inferred for the latter.

3. CONCLUSION

Sinaya Balka (Early Pleistocene, Black Sea area, Russia) is the type locality of Tamanian mammal assemblage as well as of *Elasmotherium caucasicum* and *Archidiskodon meridionalis tamanensis*. The Early Pleistocene *E. caucasicum* is confirmed as a valid species. It may be regarded as a likely morphological ancestor for *E. sibiricum* due to its primitive dental characteristics. *E. caucasicum* was dispersed in the upper part of the Early Pleistocene. Its upeer stratigraphical range is limited by Matuyama chron. The assemblage *E. caucasicum* and *A. meridionalis* tamanensis is of characteristic this time interval in southwestern Russia.

Habitats of elasmotherians included both riparian biotopes and contiguous high grass steppes.

4. REFERENCES

Borissjak, A.A. 1914. The teeth structure of *Elasmotherium caucasicum* n. sp. *Izvest. Akad. Nauk SSSR*, 6(9): 555-584. [in Russian].

Chow, M. 1958. New elasmotherine rhinoceros from Shansi. *Vertebrata Palasiatica* 2(2-3): 135-142.

Fischer von Waldheim, G. 1808. La notice d'un animal fossile de Siberie inconnu aux naturalistes. *Programme d'invitation a la seance publique de la Societe imperiale des naturalistes*: 23-28.

Qiu, Z. & Qiu, Z. 1995. Chronological sequence and subdivision of Chinese Neogene Mammalian faunas. *Palaeogeography, Palaeclimatology, Palaeoecology* 116: 41-70.

Shvireva, A.K. 1995. *History of the rhinoceros Elasmotherium*: 103 pp. Stavropol. [in Russian]

Terjaev, V.A. 1948. Geological position of the forehaed-crested rhinoceros (*Elasmotherium*). *Sovetskaya geologiya* 34: 81-87. [in Russian]

Age of some European localities with elephant remains determined by the biometric method

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SUMMARY: Using the biometric dating of lamellar frequency in the last upper molars of the *Archidiskodon-Mammuthus* elephant lineage, the age of the Liventsovka, Sinyaya Balka, Tiraspol' (Russia), Süssenborn, Mosbach (Germany), Ilford, Balderton (Great Britain), Dolni Vestonice, and Předmosti (Czech Republic) localities is determined.

1. INTRODUCTION

This work was aimed at absolute age determination by the biometric method using teeth of elephants of the *Archidiskodon-Mammuthus* phyletic lineage from a series of European localities. As indicated earlier (Pevzner & Vangengeim 1994), the lamellar fre-quency in the 10-cm-long interval of the last upper molar is one of the evolutionarily important characteristics of elephants from this lineage. The time-depen-dent changes in this parameter develop according to the areacotangent law, permitting absolute age determina-tion of bone remains and, consequently, of their host localities.

2. MATERIALS AND METHODS

Since the lamellar frequency is a highly variable parameter (depends on the size and the wearing degree of molars) leading to an erroneous age determination, we consider only localities that yielded tooth series consisting of at least ten teeth (see the table 1). These localities are associated with different genetic types of deposits. The Liventsovka (Rostov region, Russia), Tiraspol' (Moldova), Süssenborn, Mosbach (Germany), Ilford and Balderton (Great Britain) local-ities occur in alluvial sediments; the upper Paleolithic Dolni Vestonice and Předmosti (Czech Republic) sites are in the sedimentary cover deposits; and the Sinyaya Balka locality (Krasnodar region, Tamanskii Peninsula, Russia) is buried in mudflow sediments.

Liventsovka locality: We used the measurement results for 30 teeth of *Archidiskodon gromovi*.

Sinyaya Balka locality: The lamellar frequency values of *Archidiskodon meridionalis tamanensis* are calculated using the plot by Dubrovo (1963, Fig. 1).

Tiraspol' and Süssenborn localities: Dubrovo (1971) reported only on the extreme and mean lamellar frequency values for *M. trogontherii*, missing data necessary for calculating the mean square deviation (δ) and mean square error (*m*). For these localities, the mean square error in age determination (*k*) presented in the table should be considered as most probable only. The are calculated from δ values (marked by asterisks in the table) using δ/M = 11.62%, which is the average value for all other localities.

Mosbach locality (major bone bed): Data on *M. trogontherii* are evaluated using the graph published by Guenther (1968, Fig. 4), who also presented values of LLQ index for 14 M^3 from the depth range of 12.5-18 m. We converted the index to a lamellar frequency in a tooth interval 10 cm long. The parameter obtained is similar to those of 18 teeth from this locality calculated by Lister & Brandon (1991, Tab. 1).

Ilford locality. The extreme and mean values together with the mean square errors are calcu-

Tab.1 - Lamellar frequency in the 10-cm-long interval of the upper last molars (M^3) of *Archidiskodon-Mammuthus* elephants and biometric ages of the studied localities.

Locality	*n*	lim	*M*±*m*	δ	δ/*M*%	*T*	*k*
Liventsovka(l)	30	3.25-5.5	4.5 ± 0.09	0.48	10.67	2.419	+0.258 -0.223
Sinyaya Balka (2)	45	4.5-6.5	5.5 ± 0.08	0.53	9.64	0.947	+0.066 -0.060
Tiraspol' (3)	19	5.0-8.5	6.1± 0.15	0.65*		0.589	+0.072 -0.063
Süssenborn (3)	130	4.0-8.25	6.35 ± 0.06	0.67*		0.486	+0.022 -0.021
Mosbach (4)	14	5.9-8.3	7.11± 0.21	0.80	11.25	0.276	+0.047 -0.039
(5)	18	5.83-8.74	6.99 ± 0.16	0.66	9.44	0.302	+0.038 -0.034
Ilford (6)	11	7.6-9.6	8.7 ± 0.25	0.83	9.54	0.082	+0.019 -0.015
Dolni Vestonice (7)	26	7.4 -12.2	9.4 ± 0.22	1.12	11.91	0.044	+0.011 -0.009
Balderton (5)	19	7.67-12.17	9.72 ± 0.29	1.25	12.86	0.032	+0.011 -0.009
Předmosti (8)	34	8.1 -12.3	9.89 ±0.18	1.08	10.90	0.027	+0.006 -0.005
(7)	30	7.5-11.9	9.60±0.17	0.93	9.69		
(5)	43	7.61-11.8	9.45 ±0.15	1.01	10.69		

Note: *n* is number of teeth; lim is the extreme values of lamellar frequency; *M* is the mean value of lamellar frequency; *m* denotes the mean square error of *M* determination: δ is the mean square deviation of *M* values; *T* is age in Ma; and *k* is the mean square error of age determination in Ma. Data used for calculations are from the following sources: (1) measurements of V.E. Garutt; (2) Dubrovo (1963); (3) Dubrovo (1971); (4) Guenther (1968); (5) Lister & Brandon (1991); (6) Lister (1993); (7) Averiyanov *et al.* (1995); (8) Musil (1968). For explanations of figures marked by an asterisk, see the text.

lated for 11 teeth of *Mammuthus primigenius* using the graph of Lister (1993, Fig. 6).

Dolni Vestonice locality: The extreme and mean parameters for 26 teeth of *Mammuthus primigenius* and the mean square errors have been published by Aver'yanov *et al.* (1995), who discussed the measure-ment results of E.V. Urbanas.

Balderton locality: Lister & Brandon (1991) cal-culated the extreme and mean parameters together with δ value for 19 teeth of *M. primigenius* from this locality.

Předmosti locality: In this case, we used the measurement results (Musil 1968, Tab. 43 a, b) for 34 out of 40 teeth of *M. primigenius*, which display a wearing degree of 1-(1-2)-(1-3)-(1-4) and have presumably been recovered from the major cultural bed. In our calculations, we ignored data on strongly worn teeth, which considerably understate the mean lamellar frequency value (*M*). For instance, M for 34 teeth is 9.89, but for 40 teeth, six strongly worn specimens included, this value decreases to 9.53.

Somewhat different data on mammoth teeth from the Předmosti locality were reported by Averřyanov *et al.* (1995) and by Lister & Brandon (1991). The extreme lamellar frequency values are similar in both publications, but lower than that estimated by Musil. Correspondingly, the mean parameter is also lower (Tab. 1). These understated values may indicate that strongly worn teeth were present in the analysed series.

Data on the Liventsovka, Sinyaya Balka, and Předmosti localities were used as reference points for determining the locality positions on the areacotan-gent curve and for scale calibration along the X (time) and Y (morphological evolutionary parameter) axes.

An age of 2.4 Ma, the average between 2.6 Ma (the Gauss-Matuyama boundary) and 2.2 Ma (age of the Psekups locality), was adopted for the Liventsovka locality. The mean parameter (*M*) for this locality is 4.5. The Sinyaya Balka locality is dated back to 0.95 Ma, which corresponds to the mean age of the Taman faunal assemblage (Vangengeim *et al.* 1991); the respec-tive mean parameter is 5.5. The cultural bed of the Předmosti site yielded the ^{14}C age of 26.5 ka (Svoboda 1990); for this site, the mean parameter is 9.89.

Using the above data, we obtain the following for-mula:

$$T = 1.62\frac{0,141e^{0.623M} + 1}{0.141e^{0.623M} - 1} - 1.6427 \text{ Ma},$$

which is used to calculate ages of localities (*T*) and the mean square age error (*k*) (see Tab. 1).

3. DISCUSSION

All the obtained biometric dates should be considered as indicating the maximum possible age, because almost all cited publications lack data on the wearing degree of teeth. When included in statistical analysis, the parameters of strongly worn teeth substantially decrease the mean values of the lamellar frequency, and we obtain an older age.

Our dating results for the Ilford and Balderton local-ities are distinctly inconsistent with those reported recently by English researchers (Brandon & Sumbler 1991, Lister & Brandon 1991, Lister 1993). They refine the former age determinations (Mitchell *et al.* 1973, Clayton 1977, Stuart 1982).

After our request, Lister kindly donated a fragment of a mammoth limb bone from the Balderton Quarry 4e for radiocarbon analysis. The analysis was made by L.D. Sulerzhitskii at the laboratory of the Geological Institute, Russian Academy of Sciences. The obtained date of 29.6 ± 0.6 ka (GIN8743) agrees well with the biometric age (32 +11 / -9 ka) of the locality and excludes the possibility that the Balderton mammoth is older than the middle Würm mammoths from central Europe.

4. CONCLUSION

The biometric dating of the oldest Liventsovka locality does not essentially change the age accepted at present, since the biometric age is calculated with a large error. The age of the Sinyaya Balka locality was formerly adopted as equal to 0.95 Ma, i.e., to the aver-age value between 1.1 and 0.8 Ma (the time span of the Taman faunal assemblage). Our calculations allow us to reduce the possible time limit of the locality from 1 to 0.9 Ma, leaving the same mean value of the age.

The Tiraspol, Süssenborn, and Mosbach localities similar in composition of the mammal assemblages were formerly considered as close in age; namely, the Tiraspol and Süssenborn sites were assumed to be of the same age and somewhat older than the Mosbach locality. Our investigations infer that the Tiraspol locality is the oldest one, probably about 600 ka old. The Süssenborn site is 100000 years younger, and the Mosbach locality is about 200000 years younger than the latter.

Our dating results for the Ilford and Balderton localities are distinctly inconsistent with those reported recently by English researches. They refine the former age determinations. The biometric age of the Balderton site agrees well wirh the new ^{14}C date obtained for the bone sample from this locality.

5. ACKNOWLEGEMENTS

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6. REFERENCES

Averiyanov, A.O., Vartanyan, S.L. & Garutt, V.E. 1995. Small mammoth *Mammuthus primigenius vrangelensis* Garutt, Averianov et Vartanyan, 1993, from Wrangel Island

(North-eastern Siberia), *Tr. Zool. Inst. Ross. Akad. Nauk.,* 263: 184-199.

Brandon, A. & Sumbler, M.G. 1991. The Balderton Sand and Gravel: Pre-Ipswichian cold stage pluvial deposits near Lincoln, England, *J. Quat. Sci.,* 6: 117-138.

Clayton, K.M. 1977. River terraces. In Shotton, F.W. (ed.), *British Quaternary Studies*: 153-168. Oxford: Clarendon.

Dubrovo, I.A. 1963. New data on the taman' vertebrate fauna. *Byull. Mosk. 0-va Ispyt. Prir., Otd. Geol.,* 38(6): 94-99.

Dubrovo, I.A. 1971. Order Proboscidea. In Nikiforova K.V. (ed.), *Pleistotsen Tiraspolya* (The Pleistocene of Tiraspol): 92-108. Kishinau: Shtiintsa.

Guenther, E-W. 1968. Elefantenbackenzane aus den Mosbacher Sanden. *Mz. Naturw. Arch.* 7: 55-73.

Lister, A. 1993. Patterns of evolution in Quaternary mammal lin-eages. In *Evolutionary Patterns and Processes*: 72-93. London: Linn. Soc. London.

Lister, A. & Brandon, A. 1991. A Pre-Ipswichian gold stage mammalian fauna from the Balderton Sand and Gravel, Lincolnshire. *J. Quat. Sci.,* 6: 139-157.

Mitchell, G.F, Penny, L.F, Shotton, F.W. & West, R.G. 1973. A correlation of Quaternary deposits in the British Isles. *Spec. Rep. Geol. Soc. London.,* 4: 1-99.

Musil, R. 1968. Die Mammutmolaren von Předmosti (CSSR). *Paläontol. Abh., Abt. A*, Bd.III, H. 1.

Pevzner, M.A. & Vangengeim, E.A. 1994. Some general features of mammalian evolution. *Stratigr. Geol. correlation,* 2 (6): 485-491.

Stuart, A.J. 1982. *Pleistocene Vertebrates in the British Isles*. London: Longman.

Svoboda, J. 1990. Moravia during the Upper Pleniglacial. In Soffer O. & Gamble C. (eds.), *The World of 18000 BP,* vol.1: 193-203. London: Unwin Hyman.

Vangengeim, E.A., Vekua, M.L., Zhegallo, V.I., Pevzner, M.A., Taktakishvili, I.G. & Tesakov, A.S. 1991. Position of the Taman' faunal assemblage in the stratigraphical and magnetochronological scales. *Byull. Komis. Izuch. Chetvert. Perioda*, 60: 41-52.

“Proboscidean agent” of some Tertiary megafaunal extinctions

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SUMMARY: Proboscideans constantly and strongly modified Tertiary ecosystems. Their impact was mostly beneficial for herbivores, but not for the other elephant-sized mammals. So, proboscideans superseded arsinoitheres in Africa (Late Oligocene) and indricotheres in Asia (Early Miocene). Indricotheres efficiently browsed only at considerable height of standing trees. Gomphotheres, like modern elephants, were mixed browsers/grazers able to take food from different storeys owing to their long trunked snout and to tree-felling habits. They destroyed many trees. Still more trees were converted to a state inappropriate for the indricothere feeding. The Plio-Pleistocene contact of proboscideans with giant sloths did not result in either group extinction. Both were equally protected from predators and equally adapted for the efficient feeding on tree vegetation of different type.

1. INTRODUCTION

The outstanding ecosystem impact of modern elephants and other pachyderms helped to unravel the puzzle of Pleistocene ecosystem functioning and that of the Wurm mass extinctions (e.g. Owen-Smith 1988; Putshkov 1989, 1994, 1997; Schule 1990). This impact may help to understand certain previous events too.

2. PROBOSCIDEANS AND NON-HUMAN PREDATORS

Various proboscideans evolved competing with each other under the pressure of formidable creodonts and, later, of large carnivorans (mainly saber-toothed cats), killing calves, subadult and old individuals. In response, proboscideans not only increased in size, but became very ‘clever’ beasts too (Gabunia 1969). They withstood foes efficiently and their population density stabilized just below their niche capacity level. Hence, proboscideans could constantly exert a potent ecosystem-shaping impact.

3. PROBOSCIDEANS, VEGETATION AND OTHER HERBIVORES

Both modern elephants despite their differences in dentition are mixed browsers/grazers that feed in any storey using trunk, tusks and felling trees (e.g. Kingdon 1979). In most cases the extinct proboscideans were ecologically flexible and basically polyphagous too. Their trophic and landscape preferences seem to be formed more by the competition and by the accessibility of one or another kind of food than by morphological differences (e.g. Putshkov 1989, 1997; Lambert 1992; Putshkov & Kulczicki 1995).

Already early Miocene gomphotheres, true mastodonts, and dinotheres ranging from rhino to Asian elephant size increased drastically the nutrient recycling rates and vegetation cover mosaicity. They destroyed many trees both by felling and by barking them. Also many damaged trees perished from diseases, fires, wood-boring insects. Thus giants created clearings and then maintained them by the repeated browsing over regrowth. Gomphotheres shaved the bark with their pointed upper and pointed or chisel-like lower tusks aided with trunk (Lambert 1992; Putshkov & Kulczicki 1995). The long trunked snout permitted them to browse efficiently on low, medium and quite tall trees (these were often uprooted), bushes, herbs and grasses (Lambert 1992; Putshkov & Kulczicki 1995). Due to such mixed 'all-storeys' feeding habits these strong and 'clever' gregarious creatures not only lived in savannas, but created them too in seasonally dry regions, like modern elephants do.

The still large later proboscideans exerted even more strong impact on Old and New World ecosystems. This impact usually was beneficial for smaller megafauna (up to the modern black rhino size) (e.g. Owen-Smith 1988; Putshkov 1989, 1997, Schule 1990) but not for the elephant-sized mammals. Only the last aspect is considered here.

4. INDRICOTHERE 'DEMISE': DROUGHT OR GOMPHOTHERES 'ACCESSION'?

The sudden final Early Miocene extinction of impressive indricotheres (baluchitheres) (*Indricotheriidae*) has been ascribed to the fact that they were simply too big. Hence, they could not exist for a long time due to their slow generation turnover (Janis & Carrano 1991). Yet, indricotheres were taller but not heavier than large elephants (e.g. Gromova 1959) and thrived for more than 15 million years (e.g. Savage & Russell 1983).

Other version blames the increase in aridity caused by rain shadow effect of the uplift of mountain ranges from Himalayas to Dinarids (e.g. Gromova 1959; Gabunia 1969). However, open steppes have occupied most of the Inner Eurasia more than 10 million years after the indricothere extinction. At the time of extinction mountains were low and caused only moderate-scaled increase in aridity. As a result, the indricothere life zone (parklands and savannas of warm-temperate, subtropical and tropical types) expanded while closed forests contracted in range (e.g. Yassamanov 1985).

Indricotheres disappeared from the geological record soon after the gomphothere invasion from Africa (e.g. Savage & Russell 1983). Is it possible that gomphotheres with a shoulder height of 1.7-2.5 m and a weight of 1.5-3.5 tons outcompeted the indricotheres with a shoulder height of 4-6 m, head height of 6-9 m and a weight of 3-15 tons? The unravel of the puzzle seems to be just there.

Indricotheres ate twigs and stripped the bark upwards mostly at height near 4.0-8.5 m with their strong lower incisors (Putshkov & Kulczicki 1995). Earlier *Indricotherium* also used large upper incisors for the bending of high branches. Later *Paraceratherium* had small or no upper incisors while the lower ones became even larger. Gromova (1959) supposed that the former was more leaf-eating and less bark-eating than the latter. Yet, these changes reflect perhaps the giants-driven changes of tree-form rather than trophic changes (Putshkov & Kulczicki 1995). Due to the upward barking with lower incisors some trees perished, but other died back only above the leisured zone. Beneath it, trees reacted by abundant trunk-shooting. Giants, attracted by the shoots, browsed upon them repeatedly. Due to the compensatory growth the dense 'brush' of shoots appeared. Some trees, whose terminal buds were repeatedly browsed could never reach their normal height. They formed dense distorted crowns at the height convenient for the indricothere feeding. Such distorted trees made up the considerable part of all trees in the 'indricothere' savannas and parklands. The beasts found enough of leaved twigs at 3.5-8 m height (Putshkov & Kulczicki 1995). It became unnecessary to bend the branches of the remaining higher trees that were, however, more convenient for the upward barking than trees distorted as yet. These indricothere-driven changes of tree-form became the selective agent causing the mentioned changes in the indricothere dentition. Huge indricotheres damaged trees more than the modern giraffes, but far less than the elephants do. Unlike proboscideans, indricotheres could not inhabit both temperate and tropical forests. Like giraffes, they remained exclusively parkland and savanna-dwellers (Putshkov & Kulczicki 1995).

Gomphotheres came to Eurasia through the new-established land bridge. They felled trees or barked them upwards and downwards at the far lower level than indricotheres did. Neither plants nor carnivores of Asian ecosystems were adapted to gomphotheres. It is probable that at first the latter increased in number explosively (as recently elephants in Tsavo Park: e.g. Beard 1989) and occupied the indricothere range rapidly not only geologically but ecologically speaking as well (Putshkov & Kulczicki 1995). They soon destroyed many trees (both undistorted and distorted by indricotheres) in savannas, parklands and riparian forests or converted them into the non-climax state of low regrowth, bushes, scrub, dense stool-shoots, etc. Such changes were adverse neither for gomphotheres with their mixed browsing-grazing 'all-storeys' feeding nor for the most of smaller herbivores (Putshkov & Kulczicki 1995). For indricotheres the changes were disastrous. Similar to modern giraffes that can not cover their energy losses while being forced to browse upon vegetation lower than 2 m, giraffe-like indricotheres could not find enough food in tree-stands transformed by gomphotheres. Indricotheres as hindgut fermenters needed more food than the foregut fermenting and much smaller giraffes need. Probably, only small indricothere herds near forest edges did not starve to death (Putshkov & Kulczicki 1995).

After several generations gomphothere numbers should have arrived to the dynamic equilibrium with their environment. The interaction between their natality rates and mortality factors may have resulted in fluctuations of gomphothere density just below the level permitted by their trophic resources. Besides other mortality agents (diseases, periodic attrition, etc.), predators that previously killed indricothere calves had to switch to subadult gomphotheres. Certain formidable foes, as probably *Hyainailouros*, may have arrived from Africa following on their proboscidean prey 'heels'. Yet, indricothere populations could not recover. Gomphotheres with their far more developed brain (Gabunia 1969) and more flexible feeding strategy withstood the hostile factors more efficiently than indricotheres did. Hence, they constantly remained 'too numerous' and went on converting many trees to the state inappropriate for the indricothere feeding. The 'ill-fed' indricotheres brought feeble calves and often could not protect them from predators. The small residual indricothere populations were doomed to the extinction by stochastic events, although they could linger in some regions till more proboscidean species appeared due to migration and speciation processes (Putshkov & Kulczicki 1995).

5. Proboscideans and other elephant sized Mammals

Probably the small-brained arsinoitheres of African Oligocene were superseded by 'clever' proboscideans that defended their calves against creodonts more efficiently. On the other hand, the gomphotheres (and partially mastodonts and mammoths as well) coexisted with elephant sized sloths (eremotheres and megatheres) in America during late Pliocene and Quaternary times. These sloths were difficult prey for any predator due to their monstrous claws combined with exceptional strength and thick skin. Also, unlike indricotheres, they could live in both savannas and heavily wooded regions and feed efficiently on trees broken or fallen by proboscideans or by sloths themselves.

6. Conclusions

Since late Oligocene proboscideans were both giant and 'clever' creatures. Predators and other adverse agents could only confine their population density just below their niche capacity level. Hence, they strongly modified ecosystems. These changes were usually useful for smaller megafauna. For the other elephant-sized giants they may be harmful, especially if these giants were less able to withstand predators. Therefore, proboscideans superseded arsinoitheres in Africa (Late Oligocene) and indricotheres in Asia (Early Miocene). Indricotheres efficiently browsed only on trees that were tall enough. Trees distorted by their repeated browsing had abundant shoots and/or ramifications at the height of 3.5-8.0 m. Gomphotheres were mixed browsers/grazers taking food from different storeys owing to their long trunked snout and to tree-felling habits. They destroyed many trees and converted still more trees to the state inappropriate for the indricothere feeding. The Plio-Pleistocene contact of proboscideans with giant sloths in Americas did not result in either group extinction. Both were equally well protected from predators and equally well ‘equipped’ for the efficient feeding on tree vegetation of different type; both were mighty ‘tree fellers’.

7. REFERENCES

Beard, P.H. 1989. *La fin d’un Monde. Le dernier echo du Paradis*. Paris: Chene

Gabunia, L.K. 1969. *Extinctions of ancient reptiles and mammals*. Tbilisi: Metsniereba.

Gromova, V.I. 1959. *Giant rhinoceroses (Indricotheriidae)*. Moscow: Ac. Sci. USSR.

Janis, C.M. & Carrano, M. 1991. Scaling of reproductive turnover in archosaurs and mammals: why are large terrestrial mammals so rare? *Ann. Zool. Fenn.* 28: 201-206.

Kingdon, J. 1979. *East African mammals. An atlas of evolution in Africa*. (Large mammals). London, Acad. Press.

Lambert, D. 1992. The feeding habits of the shovel-tusked gomphotheres: evidence from tusk wear patterns. *Paleobiology* 18: 133-147.

Owen-Smith, N.R., 1988. *Megaherbivores. The influence of very large body size on ecology*. London; Cambridge Univ. Press.

Putshkov, P.V. 1989. *Uncompensated extinctions in Pleistocene: the supposed mechanism of the crisis*. Kiev: Inst. Zool.

Putshkov, P.V. 1994. Uncompensated Wurm extinctions. 6. Final communication: the crisis outside the Old World. *Vestnik Zoologii* 1994 (2): 65-73.

Putshkov, P.V. 1997. *Were the mammoths killed by the warming? (Testing of the climatic versions of Wurm extinctions)*. Kyiv: Inst.Zool. [*Suppl.* n.4 to *Vestnik Zoologii*]

Putshkov, P.V. & Kulczicki, A.H. 1995. The Early Miocene Drama: Mastodonts against Indricotheres. *Vestnik Zoologii* 1995 (6): 54-62.

Savage, D.E. & Russell, D.E. 1983. *Mammalian palaeofaunas of the world*. London, Addison-Wesley.

Schule, W. 1990. Landscapes and climate in prehistory: interaction of wildlife, man and fire. In J.G. Goldammer (ed.), *Fire in the tropical biota*: 273-318. Berlin, Springer

Yassamanov, N.Ya. 1985. *Ancient climates*. Leningrad: Hydrometeoizdat.

Analysis of the Early Pleistocene Elephants from Buia (Eritrea)

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SUMMARY: For the purpose of this work, we analyzed the most significant elephant specimens from Buia, a locality in the northern Danakil (Afar) depression of Eritrea (East Africa). At this site there are up to 500 meters of thick, well-exposed fluvio-lacustrine horizons, with a succession of five different vertebrate-bearing fossiliferous levels. One of these yielded, in addition to the abundant mammal fauna, a nearly complete *Homo* cranium, dated at about 1 million years on magnetostratigraphic and faunal evidence. Most of the Buia elephant material belongs to a derived form of *Elephas recki*, presenting intermediate characters between *Elephas recki ileretensis* and *E. r. recki.*

1. INTRODUCTION

In 1995 a new paleoanthropological site was discovered in the northern Danakil (Afar) depression neat the village of Buia, 110 km south of Massawa, Eritrea. Field work in the area assigned to the project – delimitated by Derawle Stream (to the North) and Wadi Mahabale (to the South) – is conducted under a joint collaborative research between the National Museum of Eritrea (NME), the Eritrea Department of Mines (DMA), the Dipartimento di Scienze della Terra (DSTF), and Museo di Geologia e Paleontologia (MGPF) of the Università degli Studi di Firenze. The Buia project has been definitely approved by the Eritrea University Research Committee and is currently fully operative.

The field surveys by the project components lead to the discovery of an almost complete Homo cranium associated with a rich early Pleistocene vertebrate fauna and with artefacts of both Oldowan and Acheullean character abundant and widespread in the area (Abbate *et al.* 1998; Rook *et al.* 1999).

The *Homo*-bearing level was dated at about 1 million years on magnetostratigraphic and faunal evidence. Among mammals, elephant remains are abundant and were recovered from many sites within the studied area.

2. METHODS

The systematic study of the Buia elephants was based on the morphological and metrical analysis of the cheek teeth, the most diagnostic and best represented skeletal parts.

Comparison with other African fossil elephants was based mainly on Maglio (1970, 1973) and Beden (1980, 1983, 1987), whose classification of *E. recki* we followed.

Six dental variables (width, height, enamel thickness, number of plates, plate frequency, and hypsodonty index; see below) were used in a canonical variate analysis (discriminant analysis) performed on the M3 data given by Beden (1983, 1987) for the Omo and Koobi Fora material, to summarize the information given by the univariate analyses.

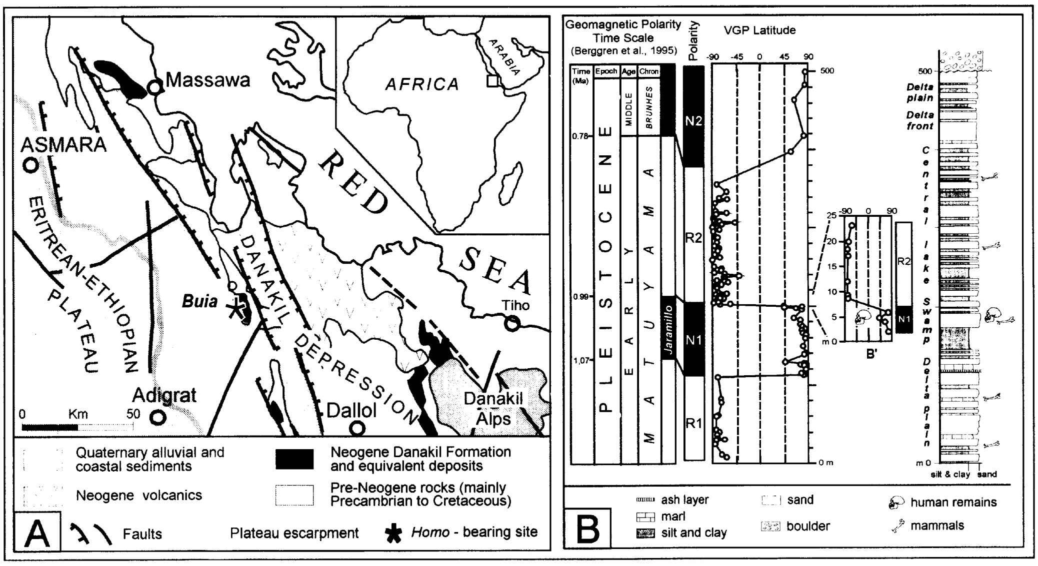

Fig.1 - A) Location map of the Buia area; B) chronostratigraphy, magnetostratigraphy, paleoenvironment reconstruction and location of vertebrate-rich fossiliferous horizons (from Abbate *et al.* 1998, modified).

3. MATERIAL

During the 1995 and 1997 surveys by the NME-DMA-DSTF-MGPF joint research project in the Buia region, a total of 109 elephant fossils, representing at least (MNI) 83 individuals, were recovered from sediments of the upper Danakil Formation outcropping in two main areas, Wadi Aalad and Dioli (Wadi Dandero). All the collected fossil material is housed at the National Museum of Eritrea.

At Aalad, from the *Homo*-bearing level (VL 3), several post-cranial elements, fragments of tusks and cheek teeth and an almost complete lower molar (UA 225), have been recovered. The lower deltaic level (VL 2), yielded isolated postcranials, some belonging to very large individuals, one tusk fragment and a deciduous premolar. An upper molar (UA 243; Fig. 2A-B) was retrieved from level VL 4, about 500 m south from the Homo site.

The elephant material from the main fossil level at Dioli includes, besides other specimens: a left and a right dP4 (DAN 74 and DAN 94); three isolated M3s (DAN 76, DAN 68 and DAN 208); a left maxillary fragment (DAN 98); the fragment of a lower molar (DAN 75); an incomplete juvenile mandible (DAN 107); a right mandible (DAN 67); another right mandible (the left portion is still in situ) (DAN 223).

An almost complete mandible (DAN 176; Fig. 2C) was collected from an older level (Dioli lower), whose position in the general stratigraphical framework of the area is not yet defined.

4. COMPARISONS

All the Aalad and Dioli molars are consistent with *Elephas recki*, the most common elephant of the Plio-Pleistocene of East Africa (Maglio 1973; Beden 1987). The systematics and evolutionary history of this long-lived species was previously characterized in a number of works mostly by Arambourg (1942, 1947), Maglio (1970, 1973) and Beden (1979, 1980, 1987), on the basis of the very rich material derived from the deposits of the Omo basin (Ethiopia), Koobi Fora (Kenya), and Olduvai Gorge (Tanzania), which span in time Middle Pliocene to Early Pleistocene.

In his systematic synthesis, Beden (1987) recognized five time-successive stages or sub-

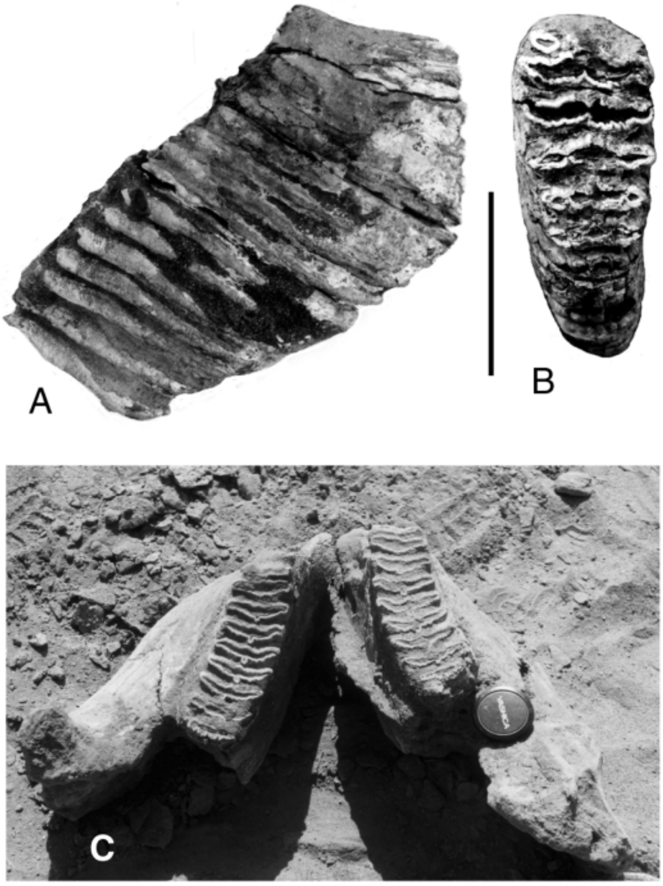

Fig.2 - Elephas remains from Wadi Aalad and Dioli (Dandero): UA243, upper molar in lateral (A) and occlusal (B) views (bar scale 10 cm); C) DAN 176, mandible in occlusal view (lens cap for scale, about 5.5 cm).

species of *E. recki*, characterized by a progressive specialization of the skull and teeth: *E. r. brumpti*; *E. r. shungurensis*; *E. r. atavus*; *E. r. ileretensis* and *E. r. recki*.

The morphometric parameters of the Aalad and Dioli elephant molars suggest a derived form of *Elephas recki*. On the average, the metrical (e.g. enamel thickness, number of plates, height) and morphological (e.g. moderately to finely wrinkled enamel, acute median enamel loops) characters of the Buia elephants are consistent with *Elephas recki ileretensis*, even though some specimens display values that bring them closer to *Elephas recki recki*. There are however also specimens with intermediate characters between these two subspecies, like as DAN 243.

Beden (1987) described *Elephas recki ileretensis* based on material recovered from Ileret (East Turkana), just above the Okote Tuff. The temporal range of this subspecies span the end of the Pliocene to the base of the Early Pleistocene. *Elephas recki recki* Dietrich, 1915 represents the last and most derived of the five subspecies of *E. recki*. The type material is from Olduvai. The chronological distribution of this subspecies seems to range from late Early Pleistocene to early middle Pleistocene.

The characters state presented by DAN 176 (Fig. 2C) hint instead to a more primitive form than *Elephas recki ileretensis*, more like *Elephas recki atavus* Arambourg, 1947. This

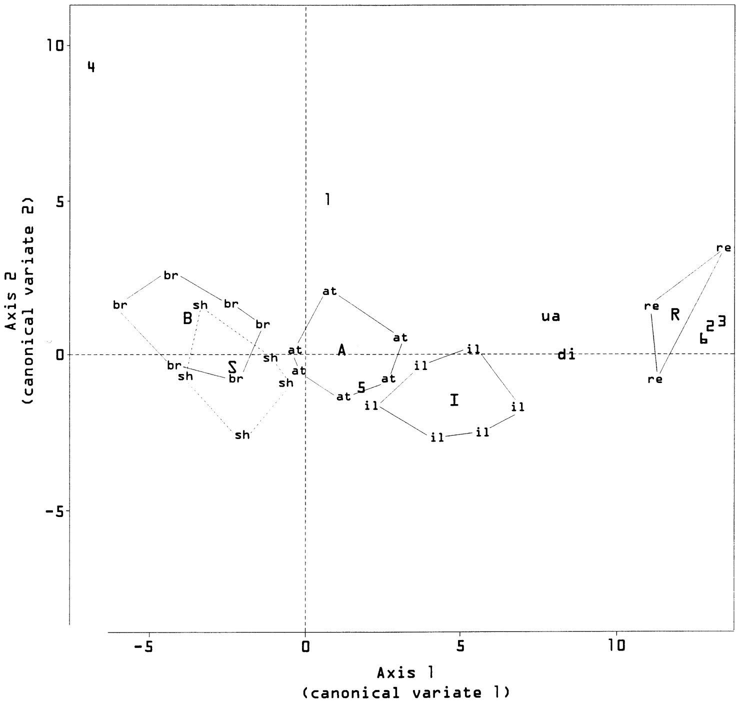

Fig.3 - Discriminant analysis biplot showing dispersion of groups (dotted lines), group centroids (capital letters) and correlation of variables with canonical variates (Ferretti *et al.* in press). Abbreviations: B (-br-), *E. recki brumpti*; S (-sh-), *E. recki shungurensis*; A (-at-), *E. recki atavus*; I (-il-), *E. recki ileretensis*; R (-re-), *E. recki recki*; ua: *E. recki* from Wadi Aalad (Buia); di, *E. recki* from Dioli (Dandero, Buia).

latter subspecies occurs in Member F (upper) and Member G of the Shungura Formation (Beden 1983, 1987). Its distribution covers the middle and late Late Pliocene and possibly the base of the Early Pleistocene. It cannot be ruled out, that the occurrence of this form represents the persistence of "primitive" or hold-over morphotypes within late *Elephas recki* populations.

5. DISCRIMINANT ANALYSIS

The discriminant analysis conducted on the M3s data set of Beden (1983, 1987), separated the five *E. recki* subspecies along the first canonical axis, which correlates with height, hypsodonty index, and number of plates (Ferretti *et al.* in press). The second canonical axis has a significatively smaller discriminant power and correlates mainly with size (width).

Enamel thickness correlates with both the first and the second variates. By plotting the scores according to the first two variates (Fig. 3), it is possible to see that *Elephas recki brumpti* and *Elephas recki shungurensis* are hardly separated and mostly by the second variates (width, enamel thickness). *Elephas recki atavus* and *Elephas recki ileretensis* form two well defined clusters. *Elephas recki recki* is separated by the first variate and isolated from all the other groups (Fig. 3). Two teeth from Dioli (DAN 76) and Aalad (UA 243) were included in the analysis. They locate between the *E. r. ileretensis* and *E. r. recki* clusters (Fig. 3), showing to possess intermediate metrical characters between these two subspecies.

6. DISCUSSION AND CONCLUSIONS

The majority of the specimens examined here were recovered from the *Homo*-bearing level, (VL 3) while the remainder (except for DAN 176) come from VL 2 and VL 4. No significant differences were observed between the samples from these three levels. Based on the estimated sedimentation rate Vertebrate level 3 is separated from either VL 2 and VL 4 by a relatively short interval of time (less than 0,2 Ma), apparently less time than exhibited in the subspecies of East African *Elephas recki*. Indeed, excluding the mandible DAN 176 (whose stratigraphic position is not fully clarified), the extent of variation presented by the elephants from Buia conforms to that of a single population. In most of the morphometrical features of the teeth, the specimens are similar to the subspecies *Elephas recki ileretensis*. Nevertheless, specimens possessing slightly more derived features also occur. Most likely the Buia sample represents a population whose evolutionary stage is intermediate between *Elephas recki ileretensis* from Koobi Fora and Ileret and *Elephas recki recki* from Beds III and IV at Olduvai. This conclusion is also supported by the results of the discriminant analysis conducted on the M3s and is consistent with the late Early Pleistocene age derived from the paleomagnetic analysis of the Buia succession (Abbate *et al.* 1998).

Presently we believe that the best interpretation is that the Buia elephant sample is referable to *Elephas recki* ex gr. *ileretensis-recki*.

7. ACKNOWLEGEMENTS

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8. REFERENCES

Abbate, E., Albianelli, A., Azzaroli, A., Benvenuti, M., Tesfamariam, B., Bruni, P., Cipriani, N. Clarke, R.J., Ficcarelli, G., Macchiarelli, R., Napoleone, G., Papini, M., Rook, L., Sagri, M., Tecle, T.M., Torre, D. & Villa, I. 1998. A one-million-year-old *Homo* cranium from the Danakil (Afar) Depression of Eritrea. *Nature* 393: 458-460.

Arambourg, C. 1942. L' *Elephas recki* Dietrich. Exposition systématique et ses affinités. *Bull. Soc. géol. France* sér. 5, 12: 73-87.

Arambourg, C. 1947. Mission scientifique de l'Omo (1932-1933). Géologie et Anthropologie. *Mus. Natl. Hist. nat. Géol. Anthropol.* 1, 3: 231-562.

Beden, M. 1979. *Les Eléphants* (*Loxodonta* et *Elephas*) *d'Afrique orientale. Systématique, phylogénie, intéret biochronologie*. Thèse d'Etat, Faculté de Sciences, Université de Poitiers.

Beden, M. 1980. *Elephas recki* Dietrich, 1915 (Proboscidea, Elephantidae): évolution au cours de Plio-Pléistocène en Afrique Orientale. *Géobios* 13: 891-901.

Beden, M. 1983. Family Elephantidae. In J. M. Harris (ed.), *Koobi Fora Research Project* 2: 40-129. Clarendon Press.

Beden, M. 1987. *Les Faunes Plio-Pleistocenes de la Vallé de l'Omo (Ethiopie), Tome 2: Les Eléphantidés (Mammalia, Proboscidea)*. Cahiers de Paléontologie. Paris.

Chavaillon, J., Guérin, C., Boisaubert, J.-L. & Coppens, Y. 1986. Découverte d'un site de dépeçage à *Elephas recki*, en République de Djibouti. *C. R. Acad. Sci. Paris*, Sér. II, 302 (5): 243-246.

Dietrich, W.O. 1915. *Elephas antiquus recki* n.f. aus dem Diluvium Deutch-Ostafrikas. In H. Reck (ed.), *Wissenschaftliche Ergebnisse, Oldoway Expedition*: 1-80.

Ferretti, M.P., Ficcarelli, G., Libsekal, Y. & Rook, L. in press. Fossil elephants from Buia (Eritrea) and the evolution of *Elephas recki* (Proboscidea, Elephantidae). *J. Vert. Paleont.*

Kalb, E.J. & Mebrate, A. 1993. Fossil elephantoids from the hominid-bearing Awash Group, Middle Awash Valley, Afar Depression, Ethiopia. *Trans. Amer. Philos. Soc.* 83 (1): 1-114.

Maglio, V.J. 1970. Four new species of Elephantidae from the Plio-Pleistocene of northwestern Kenya. *Breviora.* 342: 1-43.

Maglio, V.J. 1973. Origin and evolution of the

Elephantidae. *Trans. Amer. Philos. Soc.*, 63 (3): 1-144.

Rook, L., Ficcarelli, G., Torre, D., Clarke, R.J., Macchiarelli, R., Tesfamariam, B. & Liebeskal, Y. 1999. The Early Middle Pleistocene *Homo* bearing succession of Buia (Eritrea). *Am. J. Phys. Anthr. Suppl.* 28: 205.

Todd, N.E. 1997. *Comparison of variation in cranial and dental morphology of Elephas recki and extant elephants: implication for phylogeny and macroevolution*. Ph.D. dissertation. Washington D.C.: George Washington University.

Todd, N.E. & Roth, V.L. 1996. Origin and radiation of the Elephantidae. In J. Shoshani & P. Tassy (eds.), *The Proboscidea: Evolution and palaeoecology of elephants and their relatives*: 193-202. Oxford: Oxford University Press.

Elephas recki from Dandero, Northern Danakil Depression, Eritrea

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SUMMARY: Molar fragments assigned to *Elephas recki* (Elephantidae, Proboscidea) were collected from the Mahabale/Dandero region, about 150 km south of Massawa at the base of the eastern escarpment of Eritrea near the Red Sea coast, on the western edge of the Danakil Depression. The site has yielded abundant remains of vertebrate fossils, including reptiles and mammals. Acheulean tools, e.g., bifacial handaxes and cleavers were also found at this site. Stratigraphic sections comprise over 500 meters of middle Pleistocene fluvial and lacustrine sediments (the Upper Danakil Formation), biostratigraphically dated to circa one million years old.

1. INTRODUCTION

Elephantid material collected from the Mahabale/Dandero region (Fig. 1, Bottom), includes one large molar fragment with at least eight plates in the socket of a small partial cranium, and a fragmentary isolated molar with three plates. Cranial fragment clearly show diploe (bone air cells, typical of advanced proboscideans). The larger tooth fragment is an upper right third molar (Fig. 2, A and B), maximum plate width 98 mm, height 202 mm, occlusal length 160 mm, lamellar frequency 5, enamel is crenellated (folded) and 2.5 mm thick, hypsodonty index (height/width) is 2.06. The smaller tooth fragment is probably an upper right (based on molar wear on pretrite, height, and apparent parallel plates), possibly second or third molar, plate width at least 60 mm, height at least 145 mm, occlusal length 45 mm, lamellar frequency about 6, enamel is crenellated (but appears less folded than in the larger fragment) and is 2.95 mm thick, hypsodonty index cannot be calculated. Based on characters described in the classic works of Beden (1980, 1983, 1987) and Maglio (1973), these molars are tentatively identified as *Elephas recki* Dietrich 1915, no subspecies designation can be given as yet. We follow Maglio (1973) and use *Elephas recki*, rather than *Elephas (Palaeoloxodon) recki* as employed by Beden (1983). *E. recki* is well

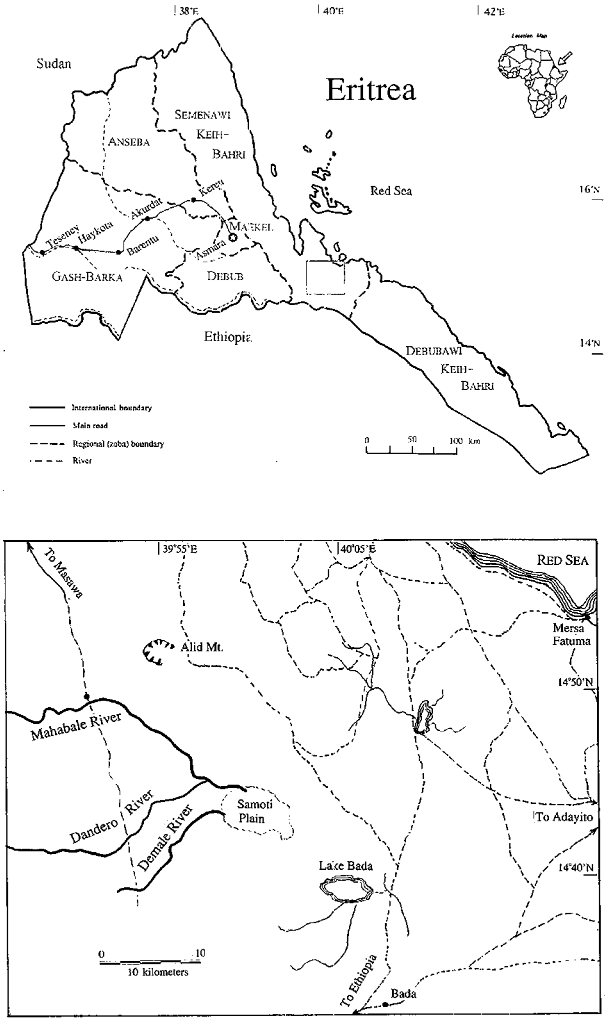

Fig.1 - TOP. A location map of Eritrea in the Horn of Africa, and a map of Eritrea. Area within the rectangle is enlarged below. BOTTOM. A simplified map of the northern Danakil region, focusing on the study area. In 1999 a team from the National Museum of Eritrea (NME) conducted a salvage/rescue collection of specimens described in this paper from Dandero River and vicinity. In 2000 a team of Italians from the Buia Project received permission to survey in the area between the Demale and Mahabale Rivers which includes the Dandero River (drawings by J. Shoshani).

known late Pliocene to middle Pleistocene taxon from Africa (Maglio 1973). Beden (1983; cf. Todd 1997) identified five subspecies of *Elephas recki*, from oldest to youngest: *E. r. brumpti*, *E. r. shungurensis*, *E. r. atavus*, *E. r. ileretensis*, and *E. r. recki*. Beden (1983) provided a phylogeny of these five subspecies.

2. FINAL REMARKS

Mahabale/Dandero is located circa 20 km south of Buia; the partial cranium of *Homo* sp. was found a few hundred meters from Buia (Abbate *et al.* 1998). Geologically and biostratigraphically we believe that the Dandero and the Buia material are comparable in age,

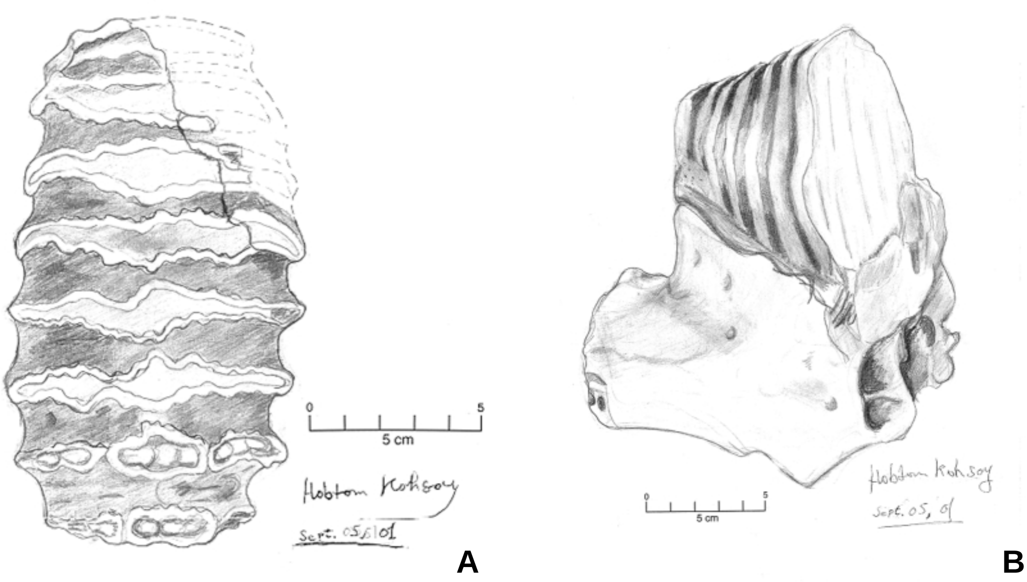

Fig.2 - A. Occlusal view of an incomplete right upper third molar of *Elephas recki* (NME 99.55) collected in Dandero River. B. A posterior three-quarter view of the molar depicted in A, with a portion of the maxilla (drawings by Habtom Kahsay from the original; note: This is an artistic rendering, thus the scale is not the same in all directions).

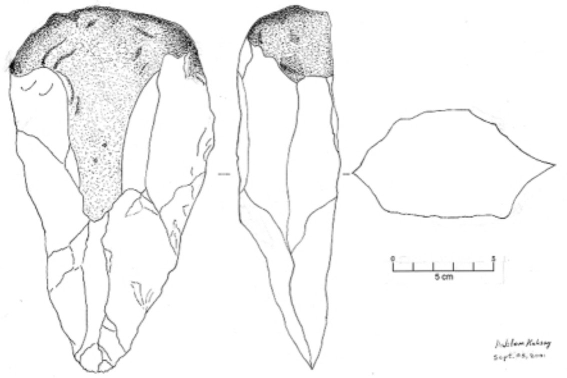

Fig.3 - A bifacial hand axe (NME CB-12-1 99.101): plan view, side view, and cross section from Cabuia, near Dandero, Northern Danakil Depression, Eritrea. This Acheulean hand axe, made from quartzite, is one of many hand axes found in Cabuia/Dandero area, dated to about one million years ago. Other tools found in this area include choppers and cleavers made from basalt, chloriteschist, garnetschist, grandiorite, granite, limestone, and quartzite (drawings by Habtom Kahsay from the original).

which is between faunal stages 3 and 4 of Maglio (1973), or between *E. r. ileterensis* and *E. r. recki* of Beden (1983), but closer to the latter. Faunal stage 3 of Maglio (1973), comparable to subspecies *E. r. ileterensis* of Beden (1983) and dated to early Pleistocene, is the typical form found in Members J, K and L of the Shungura Formation (Omo, Ethiopia), originally described from Ileret (East Turkana, Kenya), also found in Olduvai Bed II (Tanzania). Faunal stage 4 of Maglio (1973), comparable to subspecies *E. r. recki* of Beden (1983) and dated to middle Pleistocene, is found in the upper level of Member L of the Shungura Formation (Ethiopia), Koobi Fora and Olorgesailie (Kenya), and in Olduvai Beds III and IV (Tanzania).

The geology of this region has been described by Sagri *et al.* (1998) and Walter *et al.* (2000). Buffler & Walter (2001), and Walter *et al.* (1997a, 1997b) provided specific information about Mahabale/Dandero. The Acheulean tools found at Dandero include handaxes (Fig. 3), cleavers and choppers.

All fossils and artifacts collected from the Mahabale/Dandero region are housed at the National Museum of Eritrea.

3. ACKNOWLEDGEMENTS

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4. REFERENCES

Abbate, E., Albianelli, A., Azzaroli, A., Benvenuti, M., Tesfamariam, B., Bruni, P., Cipriani, N., Clark, R.J., Ficcarelli, G., Marcchiarelli, R., Napoleone, G., Papini, M., Rook, L., Sagri, M., Tecle, T.M., Torre, D. & Villa, I. 1998. A one-million-year-old Homo cranium from the Danakil (Afar) Depression of Eritrea. *Nature* 393: 458-460.

Beden, M. 1980. *Elephas recki* Dietrich, 1915 (Proboscidea, Elephantidae). Èvolution au cours du Plio-Pléistocène en Afrique orientale]. *Geobios* 13(6): 891-901. Lyon.

Beden, M. 1983. Family Elephantidae. In J. M. Harris (ed.), *Koobi Fora Research Project. Vol. 2. The fossil Ungulates: Proboscidea, Perissodactyla, and Suidae*: 40-129. Oxford: Clarendon Press.

Beden, M. 1987. Les faunes Plio-Pléistocène de la basse vallée de l'Omo (Éthiopie), Vol. 2: Les Eléphantidés (Mammalia-Proboscidea) (directed by Y. Coppens and F. C. Howell): 1-162. *Cahiers de Paléontologie-Travaux de Paléontologie est-africaine. Centre National de la Recherche Scientifique* (CNRS). Paris.

Buffler, R.T. & Walter, R.C. 2001. *Rift basins and rift processes in the southern Red Sea - northern Danakil region, Eritrea. MARGINS Education and Planning Workshop: Rupturing of Continental Lithosphere in the Red Sea/Gulf of Suez, March 17-23, 2001*: 12-13. Sharm-el-Sheikh, Sinai, Egypt.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Transactions of The American Philosophical Society of Philadelphia, New Series*, 63(3): 1-149.

Sagri, M., Abbate, E., Azzaroli, A., Balestrieri, M.L., Benvenuti, M., Bruni, P., Fazzuoli, M., Ficcarelli, G., Marcucci, M., Papini., M., Pavia, G., Reale, V., Rook, L. & Tecle, T.M. 1998. New data on the Jurassic and Neogene sedimentation in the Danakil Horst and Northern Afar Depression, Eritrea. *Museum National d'Histoire Naturelle (Paris)* 177: 193-214.

Todd, N. 1997. *Comparison of variation in cranial and dental morphology of Elephas recki and the extant elephants: implications for phylogeny and macroevolution. Ph.D. Dissertation.* George Washington University. University Microfilms.

Walter, R.C., Buffler, R.T., Berhe, S., Vondra, C., Yemane, T. 1997a. Reconnaissance Geology of the Danakil Depression of Eritrea. *IGCP Conference on Continental Rifts*, Dublin, Ireland: Dublin Institute of Advanced Studies.

Walter, R.C., Buffler, R.T., Berhe, S., Vondra, C., Yemane, T. & Andemariam, T. 1997b. Rift tectonics and sedimentation in the southern Red Sea and northern Danakil of Eritrea, *Geological Society of America, Abstracts with Programs,* 29(6): 47.

Walter, R.C., Buffler, R.T., Bruggemann, J.H., Guillaume, M.M.M., Berhe, M.S., Negassi, B., Libsekal, Y., Cheng, H., Edwards. L., von Cosel, R., Neraudeau, D. & Gagnon, M. 2000. Early human occupation of the Red Sea coast of Eritrea during the last interglacial. *Nature,* 405: 65-69.

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Proboscidean fossils from the Japanese Archipelago and Taiwan Islands and their relationship with the Chinese mainland

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SUMMARY: The colonization, evolutionary processes and the relationship between the faunas of the Japanese Islands and Taiwan Island have been summarised, based on a comparison of their fossil proboscidean taxa with those of the Chinese mainland. The comparison indicates that *Mammuthus protomammonteus* and *Stegodon aurorae* evolved in the Japanese Islands and Taiwan respectively, and that *S. shinshuensis, S. orientalis* and *Palaeoloxodon naumanni* migrated to Japan from the mainland of China. Although *P. huaihoensis* migrated to Taiwan, *P. naumanni* did not migrate there.

1. INTRODUCTION

The Japanese Archipelago and Taiwan are located along the east margin of the Asian Continent, with Japan in the north and Taiwan in the south, ranging from 45° ~ till about 24° morthern latitude. Between the Japanese island of Kyushu in the north and Taiwan are situated the Ryukyu Islands, a series of small islands belonging to Japan.

For convenience Hokkaido, Honshu, Shikoku and Kyushu, the main Japanese islands, are herein referred to as the ‘Japanese Islands’.

The faunas of all these islands were strongly influenced by local tectonic movements and climate changes, resulting in changes in the sea level in the Plio-Pleistocene. During periods of low sea level, the Strait of Korea immediately northwest of the southernmost Japanese islands, the Strait of Taiwan and the East China Sea, opposite the Ryukyu islands, were exposed as dry land, and these areas then played a central role in the migration of animals. When sea levels rose, islands were again formed, and endemic species sometimes evolved on those islands.

There are two main factors influencing the faunas in these islands. Firstly, the depth of the strait between the islands and the Asian mainland. The maximum depth of the Strait of Korea between the continent and the Japanese islands is about 130 m. Most of the depth of the Strait of Taiwan between the continent and Taiwan is less than 100 m depth. These differences suggest that Taiwan has been connected longer or more frequently to the continent than the Japanese Islands, and such a difference has greatly affected the faunal composition of these two island groups.

A second factor is latitude. The Japanese Islands are located further north than Taiwan. Nowadays, the Japanese Islands are situated in the temeprate zone, while Taiwan is situated in the subtropical zone. These difference in latitude must have resulted also in a difference in climate during the Plio-Pleistocene, which resulted in different faunas. It would have turned up as the movement of the boundary line between the Palaearctic and the Oriental that is presently located on the Ryukyu Islands.

The colonisation, evolutionary processes and the relationship between the faunas of these islands are summarized, and a comparison is made of the fossil proboscidean taxa of these islands with those of the Chinese mainland (Takahashi and Namatsu 2000).

2. JAPANESE PROBOSCIDEAN FOSSILS

In recent years Japanese Plio-Pleistocene strata have been well studied by teprochronology, palaeomagnetic stratigraphy and other dating methods, and recent studies of widespread volcanic ash deposits have allowed for the correlation of event horizons at geographically distant areas (Oda 1977; Machida *et al.* 1980; Yoshikawa *et al.* 1996; Satoguchi *et al.* 1999, etc.). Therefore, the geological horizon and the age of proboscidean fossils are known accurately.

The earliest proboscidean fossils from the Japanese Islands are found in Miocene deposits of Gifu prefecture, Honshu (Matsumoto 1926; Kamei *et al.* 1977). After the Pliocene the number of specimens increases and proboscidean fossil taxa appear in the following chronological sequence: *Shinomastodon sendaicus, Stegodon shinshuensis, S. aurorae, Mammuthus protomammonteus*, *S. orientalis*, *Palaeoloxodon naumanni* and *M. primigenius.* These fossil sites number are over 350 (Kamei 1991).

However, only two proboscidean molars have been found from the Ryukyu Islands (Tokunaga 1940; Nohara and Hasegawa 1973). Otsuka (1997) identified one of these specimens as be similar to *Mammuthus paramammonteus shigensis*, and estimated the age as the Late Pleistocene. There are too few proboscidean fossils recovered from the Ryukyu Islands to include this area in the present discussion.

3. TAIWANESE PROBOSCIDEAN FOSSILS

The horizon and the age of proboscidean fossils of Taiwan are not yet known accurately. Recently, the layers of the area in which *Stegodon* and *Mammuthus* occurred were studied. The nannofossil biostratigraphy (Shieh and Shieh, personal communication) suggests that the area involved must be placed in NN19. The boundary of NN19/NN20 is approximately 0,9 to 0,4 Ma.

We began our study in 1999 with a reexamination of 232 proboscidean molar fossils from the sea bottom around the Penghu Island and Tsiliao area near Tainan, including much new material. Our comprehensive study confirmed the presence of two species of *Stegodon*, two species of *Mammuthus* from the Early to Middle Pleistocene, and one *Palaeoloxodon* from the Late Pleistocene. There are no fossils before the Pleistocene.

4. COMPARISON OF JAPANESE AND TAIWANESE PROBOSCIDEAN FOSSILS

A comparison of Japanese and Taiwanese proboscideans by Shikama *et al.* (1975) shows two mammalian faunas in Taiwan. One was named the Cho-chen fauna, being represented by *Mammuthus armeniacus taiwanicus, S. aurorae* and *S. sinensis*.

The other was the Penghu-Tainan fauna represented by *Palaeoloxodon naumanni*. Shikama *et al.* (1975) placed the first fauna in the Middle Villafranchian and the last in the Late Pleistocene.

In the Japanese Islands, Stegodon and Mammuthus occur in the Early to Middle Pleistocene, the same age as on Taiwan. *S. aurorae* is known from the Late Pliocene to the Early Pleistocene (2.5 Ma – 1.0 Ma), M. protomammonteus from the Early to the Middle Pleistocene (1.0 Ma – 0.7 Ma), and *S. orientalis* from the Middle Pleistocene (0.5 Ma – 0.4 Ma). Using data from tephrostratigraphy and oxygen isotope stratigraphy, Konishi and Yoshikawa (1999) estimated the immigration date of *M. protomammonteus* into the Japanese Islands as 1.15 Ma, and that of *S. orientalis* as 0.62 Ma.

S. sinensis, S. (Parastegodon) akashiensis, S. (Parastegodon) aurorae, Elephas hysudricus and *M. armeniacus taiwanicus* were recorded among the Cho-chen fauna described by Shikama *et al.* (1975). *S. (Parastegodon) akashiensis* has subsequently been synonymised with *S. aurorae* (Taruno 1991), and our studies indicate that the specimens identified as *Elephas hysudricus* by Shikama *et al.* (1975) are identical to *M. armeniacus taiwanicus*. Furthermore, *S. sinensis* and *S. aurorae* of Shikama *et al.* (1975) are morphologically indistinguishable from *S. orientalis* and *S. aurorae* of the Japanese islands. Although M. armeniacus taiwanicus described by Shikama *et al.* (1975), is slightly different from *M. protomammonteus* of the Japanese Islands in the mumber of lamella and molar size, those general characters are very similar. Therefore, the proboscidean taxa from the Cho-chen fauna can be placed into *S. orientalis, S. aurorae* and *M. a. taiwanicus.*

The fossils from the Cho-chen fauna of Taiwan are considered as resedimentated fossils, and as such the chronological sequence of the proboscidean fossils cannot be decided accurately. However, based upon direct comparison with the Japanese sequence, we posit a sequence of *S. aurorae, M. a. taiwanicus* and *S. orientalis*, with the latter the most recent taxon.

Shikama *et al.* (1975) described *Palaeoloxodon* from Taiwan as *Palaeoloxodon naumanni*. However, our detailed investigations indicate that *Palaeoloxodon* of Taiwan differs markedly from *P. naumanni* of the Japanese Islands in the size and wearing pattern on the occulusal surface of the molars.

We think that three species of *Palaeoloxodon* (*P. namadicus, P. naumanni* and *P. huaihoensis*) are represented in China, and that *Palaeoloxodon* of Taiwan is the same as *P. huaihoensis*, as Qi (1999) describet. *P. naumanni* has been recorded from Japan, but *P. huaihoensis* has not.

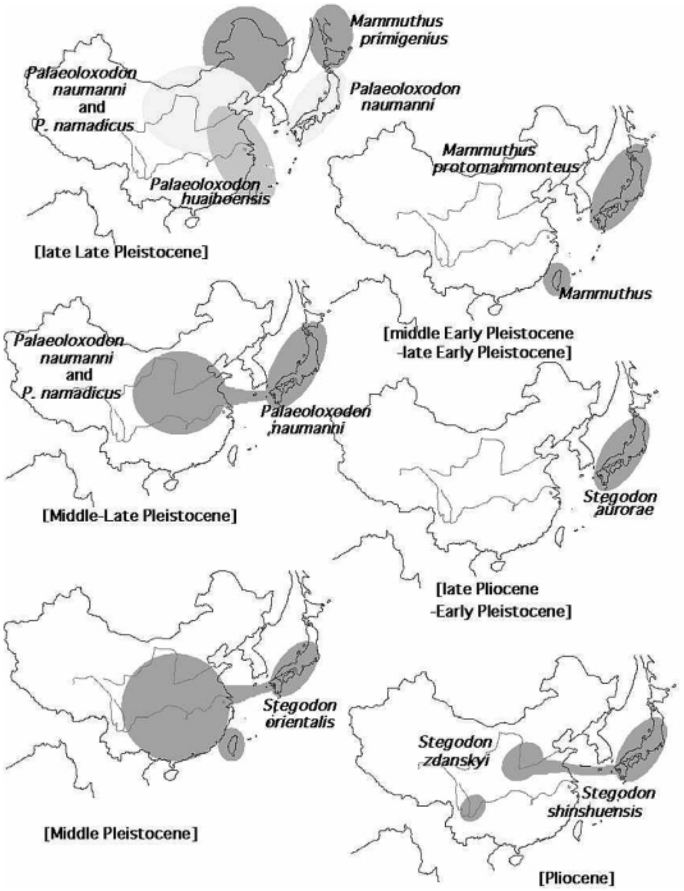

Fig.1 - Distribution maps of proboscidean fossils in eastern Asia during the Plio-Pleistocene.

The migration of *P. naumanni* into the Japanese Islands has been estimated as at 0.43 Ma by Konishi and Yoshikawa (1999). After this age, there exists no evidence that the Japanese Islands were connected with the Asian Continent. Because *Palaeoloxodon* of Taiwan is considered to be of the Late Pleistocene (Hu and Tao 1993), it is understandable that *P. huaihoensis* has not been found in Japan.

Comparison of the research results in the Japanese Islands and Taiwan with data from mainland China indicates that *M. protomammonteus* and *S. aurorae* evolved in the Japanese Islands and Taiwan, and that *S. orientalis, P. naumanni* and *P. huaihoensis* migrated there from the mainland.

5. REFERENCES

Hu, C.H. & Tao, H.J. 1993. The fossil fauna of Penghu Islands, Taiwan. *Penghu District Cultural Center Publications*: Taiwan. (In Chinese)

Kamei, T. (ed.). 1991. Japanese proboscidean fossils. *Tsukiji Shokan*: Tokyo. (In Japanese)

Kamei, T., Okazaki, Y., Nonogaki, I. & Paleontology Club, Aichi Gakuin University. 1977. On some new materials of *Gomphoterium annectens* (Matsumoto) from the Mizunami Group, central Japan. *Bull. Mizunami Fossil Museum*, 4:1-8.

Konishi, H. & Yoshikawa, S. 1999. Immigration times of the two probocidean species, *Stegodon orientalis* and *Palaeoloxodon naumanni*, into the Japanese Islands and the formation of the land bridge. *Earth Science* 53: 125-134. (In Japanese with English abstract)

Machida, H., Arai, F. & Sugihara, S. 1980. Teprochronological study on the middle Pleistocene deposits in the Kanto and Kinki districts, Japan. *Quat. Res.* 19: 233-261. (In Japanese with English abstract)

Matsumoto, H. 1926. On two new mastodonts and an archetypal stegodont of Japan. S*ci. Rep. Tohoku Imp. Univ.,* 2nd ser.(Geol.) 10: (1): 1-11.

Nohara, T. & Hasegwa, Y. 1973. An elephantoid tooth from Kyan, Okinawa-jima (Studies of the paleovertebrate fauna of Ryukyu Islands, Japan. Part III). *Mem. Nat. Sci. Mus.* 6: 59-63. (in Japanese)

Oda, M. 1977. Plantonic foraminifera biostratigraphy of the Late Cenozoic sedimentary sequence, central Honshu, Japan. *Tohoku Univ. Sci Rep.,* 2nd ser. (Geol.), 48, (1): 1-72.

Otsuka, H. 1997. On the elephant molar from Miyako island of Nansei Islands as reported by Tokunaga (1940). Abstract paper of the 1997 *Annual Meeting Paleont. Soc. Japan* 66. (in Japanese)

Qi, G. 1999. On some problemes of *Palaeoloxodon* in China. In Wang, Y. And Deng, T. (eds.), *Proc. VII Annual. Meeting Chinese Soc. Vert. Paleont.*: 201-210. China Ocean Press.

Satoguchi, Y., Nagahashi, Y., Kurokawa, K. & Yosikawa, S. 1999. Tephrostratigraphy of the Pliocene to Lower Pleistocene formations in central Honshu, Japan. *Earth Science,* 53: 275-290. (In Japanese with English abstract)

Shikama, T., Otsuka, H. & Tomida, Y. 1975. Fossil proboscidea from Taiwan. *Sci. Rep. Yokohama National University,* 2nd. sec. 22: 13-62.

Takahashi, K. & Namatsu, K. 2000. Origin of the Japanese proboscidea in the Plio-Pleistocene. *Earth Science,* 54: 257-267.

Taruno, H. 1991. *Stegodon* fossils from Japan. In Kamei, T. (ed.), J*apanese Proboscidean Fossils*: 82-99. Tokyo: Tsukiji-Shokan. (In Japanese)

Tokunaga, S. 1940. A fossil elephant tooth discovered in Miyakozima, an island of the Ryukyu Archipelago, Japan. *Proc. Imp. Acad. Japan*, 16: 122-124.

Yoshikawa, S., Satoguchi, Y. & Nagahashi, Y. 1996. A widespread volcanic ash bed in the horizon close to the Pliocene-Pleistocene boundary: Fukuda-Tsujimatagawa-Kd38 volcanic ash bed occurring in central Japan. *J. Geol. Soc. Japan,* 102, 258-270. (In Japanese with English abstract).

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Most ancient elephants from the south of Russia

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SUMMARY: The most ancient representative of the mammoth lineage in East Europe belongs to the species *Archidiskodon meridionalis* which is common on the Khapry fluviatile site near the Azov Sea. Biostratigraphy characteristics of the large vertebrates association and palaeomagnetic data of the Khapry layers testify that the chronological range of Khapry Faunal Unit is 2,6 - 2,2 Ma. Comparison between nominative subspecies of *Archidiskodon meridionalis* and *Archidiskodon meridionalis gromovi* (Garutt et Alexejeva) was done. Most of localities with the remains of these subspecies on the south of Eastern Europe are listed.

Very numerous remains of ancient representatives of the mammoth lineage on the East Europe territory belong to *Archidiskodon meridionalis gromovi* (Garutt et Alexejeva). The most part of their fossils is known from the Upper Pliocene Khapry fluviatile site of the Sea of Azov region. Biostratigraphic characteristics of the large vertebrates association and palaeomagnetic data of the Khapry layers testify that the chronological range of Khapry Faunal Unit is 2.6 - 2.2 Ma. That is, it corresponded to the time interval of the Middle Villafranchian and the most part of the zone MN 17. The faunal analysis permits a correspondance with the level of the typical middle Villafranchian Saint-Vallier Faunal Unit in West Europe. That fact is confirmed by small mammals complex, which is associated with the most part of megafauna remains Taking into account the relative simultaneity of the Khapry megafauna remains, we suggest the presence of one species of *Archidiskodon* elephant in the collection from the typical localities Khapry and Liventsovka (Gromov 1948; Garutt & Alexejeva 1964; Dubrovo, Bajgusheva 1964; Bajgusheva 1971). But the period of the accumulation of the Khapry fluviatile suite was very long (approximately some hundred thousands years), this why we can propose the presence of slightly different populations (in the range of late Pliocene) in the elephant sample.

A. m. gromovi differs from *A. m. meridionalis* and other representatives of the genus by a more elongated skull in sagital direction (ratio of the skull length to height - 86%), narrow forehead and the position of the nape regarding to the occlusion surface of upper teeth by an angle of nearly 90°, and by a more convex parietal part.

Figures of the abrasion on the occlusion surface are of unsteady, "meridionaloid" type, as a rule consisting of three ovals. Molars are low and wide (the crown wide is 80-85% of the height, hypsodonty index: 1,03-(1,29)-1,44). From teeth of typical *A. m. meridionalis* Nesti from Upper Valdarno (Italy), Seneze, Chagny (France) and several middle and late Villafranchian localities of Central, West and South Europe (Azzaroli 1977; Maglio 1973; Lister 1996) fossils from Khapry and Liventsovka differed, on an average, by a smaller plate number (M^3: 11-(13)-15, M_3: 12-(13,7)-15 together with talon) and more little lamellar frequency (Figs. 1, 2). Whereas some different time of Upper Valdarno localities, it is difficult to speak about the absolute reliability of the sample of this meridionaloid elephants. Numerous elephant teeth collections from one locality in West Europe are not frequent, and

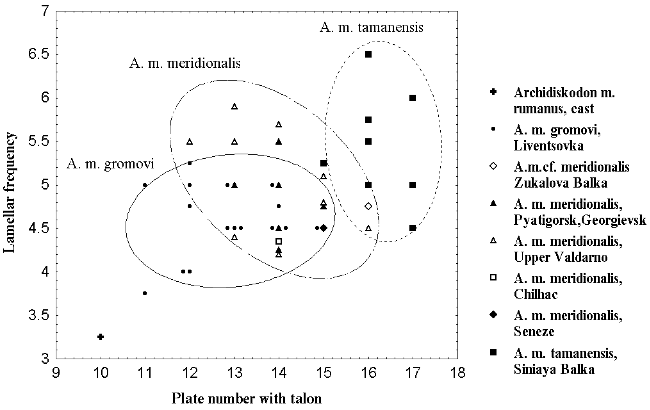

Fig.1 - Ratio of plate number and lamellar frequency of upper M^3 of some *Archidiskodon* representatives.

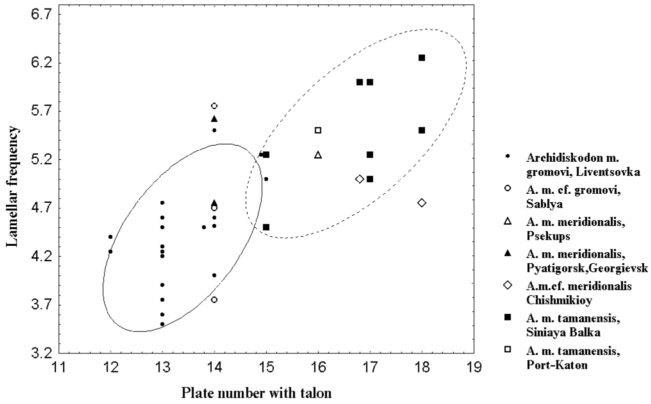

Fig.2 - Ratio of plate number and lamellar frequency of lower M_3 of some *Archidiskodon* representatives.

available data about teeth parameters of *A. m. meridionalis* (Maglio 1973) include data from different sites, as a rule. Molars of *A. m. gromovi* differ from those of other genus representatives by lower (height of unobliterated M^3: 105-(126.7)-147 mm, M_3: 108-(123.7)-134 mm) and relatively wide crowns (M^3: 88.2-(102.7)-121, M_3: 77-(96.4)-107). The elephant from Khapry layers has a higher plate number in comparison with more archaic *A. m. rumanus* Stefanescu from Romania (Fig. 1).

Molars of the Khapry elephants have similar lamellar frequency and enamel thickness as teeth of “primitive” type of meridionaloid elephants from Norwich Crag - England (Falconer, Cautley 1868), Montopoli, Laiatico, San Regolo, San Miniato, Incisa Belbo - Italy (Azzaroli 1977), Aszod - Hungary, Tulucheshty - Romania, Farladany - Moldavia (Pavlow 1910), Podpusk - Western Siberia, Kuruksay - Tadjikistan.

W. Maglio (1973) attributed remains of *Archidiskodon* elephants from early and middle Villafranchian sites of West, Central and South Europe to *A. meridionalis* “Laiatico stage”. But this fragmental material does not allow to compare it with the teeth collection of the Khapry association elephant.

Remains of *A. m.* cf. *gromovi* in situ are known from the Upper Pliocene marine deposits of Upper Akchagyl in the Kushkuna locality (Northern Caucasus) (Lebedeva 1972).

The M3 of the elephant from the village Sablya have the same parameter (Stavropol region) (Fig. 1).

There are known remains of elephants similar to typical *A. m. meridionalis* from the Psekups locality (Bakinskaya and Saratovskaya villages, Krasnodar region), included in Psekups Faunal Unit (terminal Pliocene - early Pleistocene) (Gromov, 1948). M^3 of *A. m.* cf. *meridionalis* were discovered on the northern bank of the Sea of Azov (Berdiansk town, Zukalova Balka), too (Bajgusheva 1984). Few M3 of *A. m. meridionalis* were taken from the Georgievsk and Piatygorsk localities. Several teeth of *A.* cf. *meridionalis* from the neighbourhood of Grozny city (Northern Caucasus) were found in the Lower Pleistocene Apsheron deposits. The incomplete skeleton, which was described as *A. m. taribanensis* Gabunia et Vekua, 1963 (= *A. m. meridionalis* by V.E. Garutt) was excavated in transitional Upper Pliocene - Lower Pleistocene layers of Georgia (Taribana site). In the same deposits of Azerbaidjan (Duzdag locality), remains of *A. m.* cf. *meridionalis* were found.

The next evolutionary stage of A. *meridionalis* of East Europe is the Pleistocene southern *A. m. tamanensis*. The comparison of large series of M3 of *A. m. gromovi* with the same of *A. m. tamanensis* from Siniaya Balka (Taman peninsula) shows the overlapping of some absolute and relative data (length of the crown, lamellar frequency) of M^3 and M_3 of that form (especially in the upper teeth). They differ by plate number, lamellar frequency and height of crown (Tamanian elephant have higher index values). Some remains from Lower Pleistocene deposits near Samarskoe village, Port-Katon village (Rostov region), Obitochnoe village (Zaporozhiye region, Ukraine) are attributed to that form of *Archidiskodon* elephant (Bajgusheva 1984).

Bones of the postcranial skeleton of *A. m. gromovi* have similar measurements and proportions as those of nother elephants of that genus. But it was smaller (Fig. 3), its height at the withers was nearly 3.1 - 3.3 m.

The species belonging to the elephant of Khapry Faunal Unit is the subject of discussion, yet. But, taking into account some of its differences from typical *A. m. meridionalis*, we suppose this form of elephant to be a separate taxonomic unit at a subspecies range. The presence of a more primitive "southern elephant" in Europe is marked by several investigators (Azzaroli 1977; Maglio 1973; Lister 1996).

The variability in skull structure of

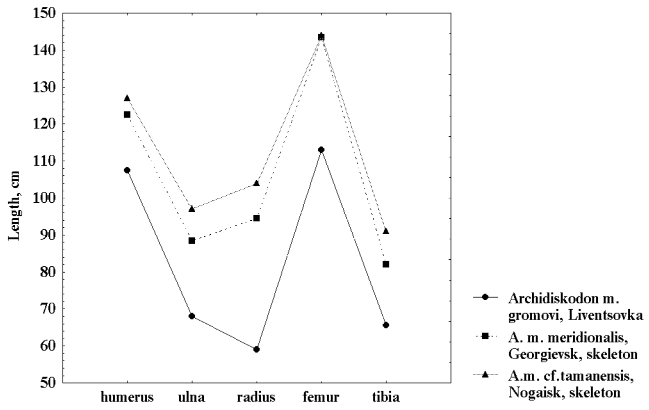

Fig.3 - Proportions of limb bones of some *Archidiskodon* from the south of Russia
Archidiskodon m. gromovi from the collection of Rostov and Azov local museums; *A. m. meridionalis*, Georgievsk; *A. m.* cf. *tamanensis*, Nogaisk (by Garutt, 1954).

Archidiskodon testifies about its significant variety and about slightly different specialisations. The taxonomic variety of *Mammuthus* (allied Proboscidian group) is the confirmation of that fact; there are several taxons of species and subspecies range in Pleistocene. All of them were characterised by features of teeth morphology and skull. Insufficient number of discovered skulls of *Archidiskodon* from one locality does not allow about the variability within of one taxon.

Teeth parameters of almost all *Archidiskodon* are overlaying significantly (Figs. 1, 2). Even the length of unobliterated tooth and plate number (most diagnostic features of elephant's dental system) overlap between close taxons because of their relatively slow evolutionary changes and the similarity of the food base. Differences of such features as enamel thickness, lamellar frequency, height of crown are considerable between evolutionary far away forms. This is why for the characteristic of teeth all parameters are necessarily complex. Observing distinctions between different *Archidiskodon* groups we interpret them as subspecies of *A. meridionalis*. Change in teeth characteristics were originated during a period of increasing aridity.

Taking into account landscape and climatic differences between various districts of *Archidiskodon* area in Eurasia, we can suppose the extension of some subspecies (or species) on that territory during different periods of the Plio-Pleistocene. It is possible that elephants from West and East Europe were representatives of various subspecies, which were geographically remote from each other. Very likely the level of *A. m. gromovi* corresponds with the group of *A. meridionalis* "Laiatico stage" from Montopoli, Laiatico, Le Serre, Incisa, San Regolo (Italy), (Maglio 1973; Azzaroli 1977). But these fossils are very fragmental and are not determinated exactly (Dubrovo 1990). *A. m. meridionalis* from West, Central and South Europe display similarities with numerous but odd remains of *Archidiskodon* from early Pleistocene localities of the South Black Sea territory and Northern Caucasus. The latest form of *Archidiskodon* from the Azov Sea region - *A. m. tamanensis* is biometrically close to *A. m. vestinus*.

The presence of constant last upper premolars is determined by species authors (Alexeeva, Garutt 1965) as the distinction of *A. gromovi*. It is regarded as the primitive index of that species. This premolar is on the incomplete skull from Khapry sandpit (GIN 300/122). This tooth is a reduced permanent premolar, which consists of some row of tubercles. On this skull "P^4" and M^1 were functioned simultaneously, that is why V.I. Gromov (Gromov 1977) and V.E. Garutt (Garutt *et al.* 1977) supposed the vertical rotation of the first teeth generation for the elephant of the Khapry Faunal Unit. Another investigator considered this fact as atavism (Dubrovo 1989) or the breaching of dp^2 development (Maschenko 2000).

The constant premolar is known reliably only for *Protelephas planifrons* Falkoner et Cautley. But the presence of the same feature was spotted on remains of *Elephas celebensis* Hoojer, *A. meridionalis, Mammuthus imperator* Seidi, *M. trogontherii* Pohlig *"Protelephas proplanifrons"* Osborn (Gromov 1977).

It is known that atavism and abnormal development are very rare in natural populations and that the probability of finding them in the geologic record is very small. The presence of constant teeth rotation of premolar on skull of *A. m. gromovi* suggests normality of this possibly rudimentary feature for the taxon.

The enviroment of *A. m. gromovi* was probably the same as modern African elephant. The structure of the Khapry fauna, which looks like that of the modern African savannah, speaks about this fact. Paleopalynological data testify the domination of steppe and forest-steppe landscapes on the territory of the Azov Sea region at the end of the Pliocene. The relatively small lamellar frequency and thick enamel on teeth of this elephant (in comparison with later forms) attests their more soft and less abrasive food - foliage, twigs and high grass. The more elongated humerus of *Archidiskodon* comparated to the humerus of mammoth also indicates this. The proportions of "Gromovy elephant" skeleton look like those of skeletons of southern elephants. They had long limbs and a short body. This suggest that he was living in half-opened landscapes (Garutt, 1954, 1998). It is possible that the forests were occupied by *Phanagoroloxodon mammonthoides* Garutt (Garutt 1957) on the territory of the Sea of Azov at the end of Pliocene and at the beginning of the Pleistocene.

REFERENCES

Alexeeva, L., Garutt, V. 1965. New data on the evolution of elephants genus *Archidiskodon*. *Bull. Com. Res. Quatern. Period* 30: 161-166.

Azzaroli, A. 1977. Evolutionary Patterns of Villafranchion Elephants of Central Italy. *Mem. Acad. Naz. Lin.* Serie 8., 14: 150-168.

Baigusheva, V. 1971. Fossil theriofauna of Liventsovka (North-Eastern Azov Region). *Proc. Zool. Inst. Acad. Sci. USSR* 49: 5-29.

Baigusheva, V. 1984. Late Neogene and Early Pleistocene faunas of proboscids and ungulates of Azov region and some of their correlation ties with Villafranchian faunas of Western Europe. *Anthropogene of Europe*: 168-175.

Dubrovo, I. & Baigusheva, V. 1964. Elephants of Khapry faunistical complex. *Bull. Moscow Soc. Invest. Nat.* 39: 133-136.

Garutt, V. 1954. South elephant *Archidiskodon meridionalis* (Nesti) from the Pliocene of the northern coast of Azov Sea. *Proc. Com. Res. Qatern. Period.* 10/2: 1-77.

Garutt, V. 1957. New data about most ancient elephants. Genus *Protelephas* gen. nov. *Reports Acad. Sci. USSR* 114, 1: 189-191.

Garutt, W.E. 1998. Is there a genus *Archidiskodon* Pohlig, 1885, on the family Elephantidae Gray, 1821? *Cranium* 15, 1: 15-20.

Garutt, W.E. & Alexeeva, L.I. 1964. New data on the evolution of elephants of the genus *Archidiskodon*. *Novosibirsk*: 7-8.

Garutt, W.E., Alexeeva L.I., Bajgusheva, V.S. 1977. On the *Archidiskodon* Elephant from the antropogene of USSR. J*ournal of the Paleontological Society of India* 20: 4-9.

Gromov, V. 1948. Paleontological and archeological statement of stratigraphy of continental deposits of Quaternary Period on the territory of the USSR. *Proc. Geol. Inst.* 64: 1-521.

Gromov, V. 1977. The skull of elephant from Khapry. *Pal. Strat. Anthrop.*: 83-94.

Lebedeva, N. 1972. Geological position of the remains of terrestrial mammals of Khapry, Taman' and Tiraspol faunistical complexes in the cut of marine layers of Akchagyl and Apsheron of Eastern Transcaucasia. *Bull. Com. Res. Quat. Per.* 38: 99-117.

Lister, A. 1996. Evolution and taxonomy of Eurasian mammoths. *The proboscidea: Evolution and paleontology of elephants and their relatives*: 202-213.

Maglio, V.J. 1973. Origin and evolution Elephantoidea. *Transaction of the American Philosophical Society* 63, 3: 3-149.

Pavlow, M. 1910. Les Éléphants fossiles de la Russie. *Nouveaux Mémoires de la Société Imériale des Naturalistes de Moscou*. 17: 1-57.

Pliocene faunas with Proboscideans of the Former Soviet Union

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SUMMARY: In the territory of the former Soviet Union, remains of proboscideans are known in Pliocene faunas from Moldova to the Transbaikal region. They belong to four genera and seven species of four families: Deinotheriidae, Mammutidae, Gomphotheriidae and Elephantidae. During the early Pliocene, mammutid and gomphothere mastodonts prevailed. The first elephantids of the *Archidiskodon – Mammuthus* lineage dispersed together with other inhabitants of open landscapes in the south of that territory in the middle Pliocene (MN 16). The members of that lineage became widespread in the south of Northern Eurasia beginning from the late Pliocene (MN17) after 2,5 Ma.

1. INTRODUCTION

Proboscideans were among the dominant groups in the Pliocene and Pleistocene mammalian faunas of Northern Eurasia. Data on their occurrences are traditionally used in the biostratigraphy of these stages.

The Pliocene was a time when the first members of the *Archidiskodon-Mammuthus* lineage dispersed into Eurasia. During a part of that epoch they co-existed there with other proboscidean groups. The evolution of proboscideans as well as of other herbivores was closely related to palaeoenvironments and coincided with the large environmental changes. The history of proboscideans in the Pliocene of Northern Eurasia reflects the increase of global cooling accompanied by the enlargement of open woodlands in the temperate latitudes.

In the territory of the former Soviet Union (FSU), remains of Pliocene proboscideans are known from the numerous well-dated localities of Moldova, Ukraine, southern Russia, Georgia, Kazakhstan, Uzbekistan, and Tadzhikistan. The data on proboscideans from the FSU offer important insights into the history of this group, its occurrences and dispersals.

2. EARLY PLIOCENE

The early Pliocene (Ruscinian) faunas of the FSU lived in a more continental climate than that of Western Europe. Despite this, the Ruscinian faunas of the European part of the FSU contained many forest inhabitants including proboscideans, cercopithecid primates (*Macaca* sp. and *Dolichopithecus* cf. *ruscinensis*), various muntiacines, pliocervines and others (Vangengeim *et al.* 1998).

Proboscideans were represented by three families: Deinotheriidae, Mammutidae and Gomphotheriidae (Fig. 1). They were found in the European part of the FSU and belonged to three genera, *Deinotherium, Zygolophodon* and *Anancus*, which appeared in the Miocene.

Remains of *Deinotherium* have been found in the northern Ciscaucasus: *D.* cf. *gigantissimum* near the Armavir town and *Deinotherium* sp. in Kosyakino near the Stavropol town (Alekseeva 1977).

In the northern Black Sea area, a mammutid *Zygolophodon borsoni* (= *Mammut borsoni*) was most abundant in the first part of the Ruscinian. The remains of this species are recorded in Ukraine (Novopetrovka and elsewhere) in the Kuchurgan Beds (MN 14 and initial part of MN 15) and in Moldova in the

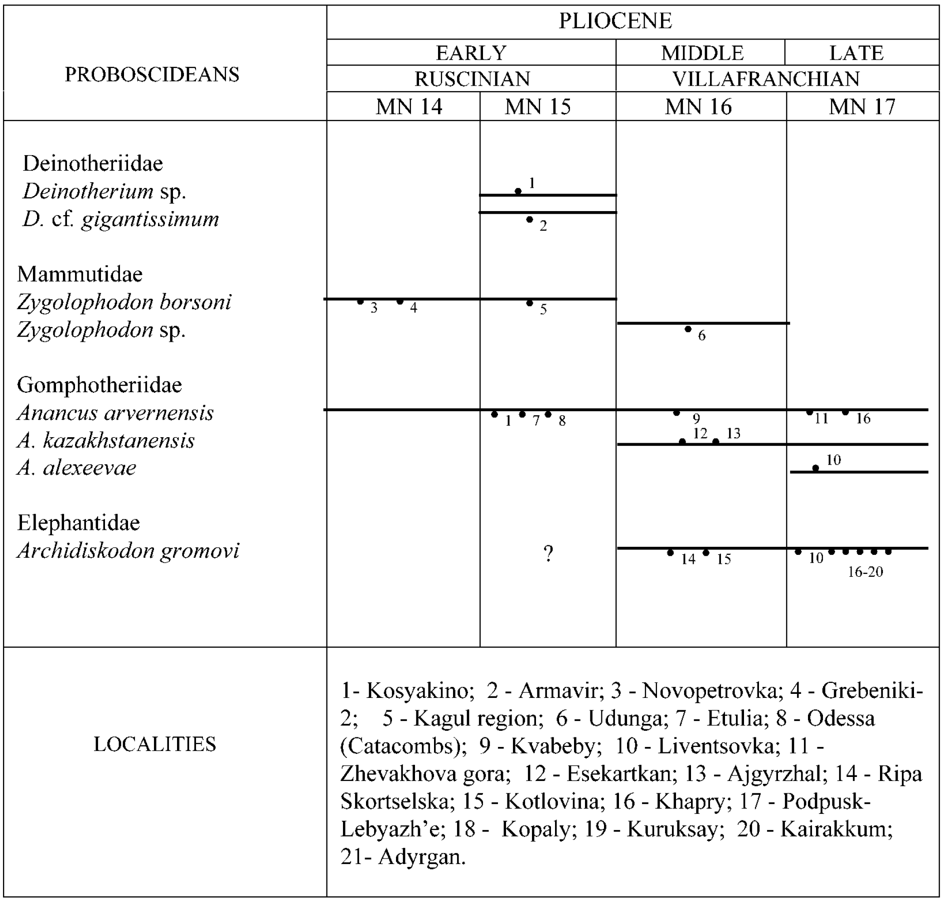

Fig.1 - The main localities and occurrences of proboscideans in the Pliocene of the FSU.

"Moldavian Russilion" (MN 15) (Vangengeim et *al.* 1998).

A gomphothere *Anancus* was more common in the south of European part of the FSU during the late Ruscinian. Its dispersal in this territory coincided with the appearance of some inhabitants of open landscapes due to more arid climatic conditions than in the first half of the Ruscinian. The remains of *Anancus arvernensis* occurred in Moldova (Etuliya, Luchesty and others) in the Karboliya Beds (late part of MN 15) and in the northern Ciscaucasus (Kosyakino) (Vangengeim *et al.* 1998). In the northern Black Sea area, that species co-existed with camels *Paracamelus*, which dispersed there again after its first appearance there in the Messinian time (Vislobokova *et al.* 2001). The appearance of a small canid *Eucyon odessanus* is also indicated at this time.

3. MIDDLE-LATE PLIOCENE

3.1 Early Villafranchian

At the Early/Middle Pliocene (Ruscinian/Villafranchian) transition, the number of inhabitants of open landscapes markedly increased. During the middle and late Pliocene, mastodonts were gradually replaced by elephantids.

The early Villafranchian faunas of the FSU are characterised by the last occurrence of some warmth-requiring forest elements including *Zygolophodon*, a procyonid (*Parailurus*), a large badger (*Parameles*), and a further radiation of *Eucyon*-like canids; and by the first appearance of a number of boreal forms.

The most north-eastern finding of *Zygolophodon* occurred in Transbaikal region in the Udunga fauna (MN 16), one of the most representative faunas of this age in the Asian part of the FSU. The Udunga fauna also contains a cercopethecid primate Parapresbytis, a small bear *Ursus* cf. *minimus*, and the first boreal forms (*Gulo, Capreolus* and others) (Kalmykov 1992, Sotnikova & Kalmykov 1991, Vislobokova *et al.* 1993, 1995; Vislobokova *et al.* 2001).

Anancus continued to exist in some refugia in the south of Northern Eurasia. The genus was represented by *A. arvernensis* in the Caucasus (Kvabeby) and by *A. kazakhstanensis* in the Tekess Depression in southern Kazakhstan (Esekartkan and Ajgyrzhal). Mastodonts occurred there together with progressive hipparions.

The first records of the *Archidiskodon–Mammuthus* lineage, of African origin, are observed in the south-western FSU in middle Akchagylian times. But *Archidiskodon* could have arrived there before that time. Alekseeva (1977) supposed that *A.* cf. *meridionalis* from Kosyakino could be *A. gromovi* but this presumption needs to be checked. In Italy, the entry of *Archidiskodon* occurred at the second half of the early Villafranchian (Montopoli) (Azzaroli *et al.* 1988). In Roumania, *Anancus arvernensis* and a primitive *Archidiskodon* are reported from the Dacic Bassin (MN 16b) (Tersea *et al.* 1997). In China, a record of *Archidiskodon-Mammuthus* lineage in the Yushe Basin is referred to MN 15 zone (Tedford 1995).

3.2 Middle Villafranchian

The middle Villafranchian faunas of the FSU are characterized by the diversity and last occurrence of *Anancus*, and a wide distribution of elephantids. *A. arvernensis* is reported from Ukraine (Zhevakhova gora) (Alekseeva 1977). A progressive *A. alexeevae* was discovered in the south of European Russia (Liventsovka) (Baigusheva 1971). *A. kazakhstanensis* is present in Kazakhstan (Adyrgan) (Tleuberdina 1988). In Europe, *Anancus* persisted until the early Pleistocene (Göhlich 1999).

The elephantids of the *Archidiskodon-Mammuthus* lineage became widespread together with other animals adapted to savanna-like conditions: *Canis etruscus* group, *Pliocrocuta, Homotherium, Acinonyx, Equus, Paracamelus, Elasmotherium* and others. *A. gromovi* was found in a number of localities in the south of European Russia (Khapry, Liventzovka and others), in Kazakhstan (Podpusk-Lebyazh'e, Kopaly, Tadzhikistan (Kuruksay) and in Uzbekistan (Kairakkum)) (Baigusheva 1971; Sotnikova *et al.* 1997; Vangengeim *et al.* 1988; Vislobokova 1996).

In the faunas of the terminal Pliocene of the FSU, mastodonts are unknown and *A. gromovi* is replaced by *A. meridionalis.*

4. FINAL REMARKS

A large diversity of proboscideans was typical of late Ruscinian faunas in the territory of the FSU, characterized by the presence of deinotheres, gomphotheres and mammutid mastodonts and, possibly, by the first appearance of the *Archidiskodon-Mammuthus* lineage.

The main turnovers of proboscideans in this territory coincided with a wide spread of open landscapes at the early Pliocene/middle Pliocene transition (about 3,5 Ma) and at the middle Pliocene/late Pliocene transition (about 2,5 Ma). In the middle Villafranchian a primitive *Archidiskodon - A .gromovi* - became dominant; in some regions these elephants coexisted with *Anancus*.

At the end of Pliocene proboscideans in the FSU were represented by the single family Elephantidae (*A. meridionalis*).

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6. REFERENCES

Alekseeva, L.I. 1977. *Early Anthropogene theriofauna of East Europe*. Moscow: Science.

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

Baigusheva, V.S. 1971. Fossil theriofauna of the Liventzovka sand-pit. *Transaction of Zoological Institute*, 49: 5-29.

Göhlich, U.B. 1999. Order Proboscidea. In G.E. Rössner & K. Heissig (eds.), *Land mammals of Europe*: 157-168. München: Verlag Dr. F.Pfeil.

Kalmykov, N.P. 1992. *Biostratigraphy and mammalian fauna of the Pliocene of Transbaikal*. Novosibirsk: Science.

Sotnikova, M.V., Dodonov, A.E. & Pen'kov, A.V. 1997. Upper Cenozoic bio-magnetic stratigraphy of Central Asian mammalian localities. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 133: 243-258.

Sotnikova, M.V. & Kalmykov, N.P. 1991. Pliocene Carnivora from Udunga locality, Transbaikal, SSSR. In E.A. Vangengeim (ed.), *Pliocene and Anthropogene palaeogeography and biostratigraphy*: 146-160. Moscow: Geological Institute.

Tedford, R.H. 1995. Neogene mammalian biostratigraphy in China: past, present and future. *Vertebrate Palasiatica,* 33 (4): 277-289.

Tersea, E. 1997. Biochronologie du Pliocène du bord méridional du Bassin Dacique (Roumanie). In J.P. Aguilar, S. Legendre & J. Michaux (eds.), *Biochronologie mammalienne du Cénozoïque en Europe et domaines reliés*: 649-660. Actes du Congrès BiochroM'97 Montpellier.

Tleuberdina, P.A. 1988. Main localities of hipparion fauna and their biostratigraphic correlation. In E.I. Gavrilov (ed.), I*nterregional comparison of faunas and floras of Mezozoy and Cainozoy of Kazakhstan*: 38-73. Alma-Ata: Science.

Vangengeim, E.A., Sotnikova M.V., Alekseeva, L.I., Vislobokova, I.A., Zhegallo, V.I., Zazhigin, V.S. & Shevyreva, N.S. 1988. *Biostratigraphy of Late Pliocene – Early Pleistocene of Tadzhikistan (based on mammalian fauna)*. Moscow: Science.

Vangengeim, E.A., Vislobokova, I.A. & Sotnikova, M.V. 1998. Large Ruscinian Mammalia in the territory of the former Soviet Union. *Stratigraphy and Geological Correlation* 6(4): 368-382.

Vislobokova, I.A. 1996. The Podpusk-Lebyzh'e mammalian faunas and assemblage, Western Siberia. *Palaeontographia Italica* 83 (1-5): 1-23.

Vislobokova, I., Dmitrieva, E. & Kalmykov, N. 1995. Artiodactyls from the late Pliocene of Udunga, Western Trans-Baikal, Russia. *J. Vertebrate Paleontology* 15(1): 146-159.

Vislobokova, I.A., Erbaeva, M.A & Sotnikova, M.V. 1993. The early Villafranchian stage in the development of the mammalian fauna of Northern Eurasia. *Stratigraphy and Geological Correlation* 1(5): 555-564.

Vislobokova, I.A., Sotnikova, M.V. & Dodonov, A.E. 2001. Late Miocne - Pliocene mammalian faunas of Russia and neighbouring countries. *Bolletino della Società Paleontologica Italiana* 40: 307-313.

Abruzzo (Italy): the Plio-Pleistocene proboscidean-bearing sites

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SUMMARY: This work represents the preliminary updated revision of the Plio-Pleistocene proboscidean-bearing sites of Abruzzo. Findings to date amount to 25, including mentions in the literature and new reports. From the stratigraphical point of view the outcropping sequences in these sites altogether embrace a lapse of time spanning from the middle of the Early Pleistocene to the end of the Middle Pleistocene, and consist of lacustrine, fan delta and alluvial plain facies. The sites are located in both the Apennine chain and in the area between the mountains and the present-day Adriatic coastline. The species found are: *Mammuthus (A.) meridionalis; Mammuthus (A.) meridionalis vestinus; Mammuthus (M.) trogontherii; Elephas (P.) antiquus*.

1. INTRODUCTION

Since the second part of the 19th century many remains of proboscideans have been discovered in Abruzzo. They had been identified on the basis of the paleontological knowledge of the time or the geological age of the bearing sediments. The excavation by Maccagno and co-workers in 1954, when an almost complete specimen of *Mammuthus (A.) meridionalis vestinus* was recovered in the Santarelli quarry near Scoppito (L'Aquila), raised great public interest. A plentiful of reports of remains found thereafter increased the attention and care of local population to the paleontological and prehistoric archaeological matters. Nonetheless, only some of these large mammal remains are now kept in various museums. In fact, the specimens described in the earliest reports are now lost to record and the only witness of their existence consists in the descriptions of the sites of discovery and in reports of uncertain accuracy by those who examined the remains.

In the occasion of the 1st international Congress "La Terra degli Elefanti" we present the preliminary results of a revision under way of all known data on the sites in Abruzzo which provided proboscidean remains, and also the first reports on the new findings of the last 20 years. The need for such a revision was felt to improve our knowledge of the territory and to predispose a more effective protection of the remains and of the most important and best preserved fossil-bearing outcrops and type sequences. An analysis of the existing files and field surveys were carried out in the frame with other geological studies of the Quaternary performed in key areas of the region (Fig. 1).

2. DISCUSSION OF THE DATA

The elephant remains discovered from L'Aquila basin and from the Aterno valley both within the Apennine chain, were contained in lacustrine sediments of the Early Pleistocene second cycle outcropping in the area of Madonna della Strada near Scoppito (*Mammuthus (A.) meridionalis vestinus*)

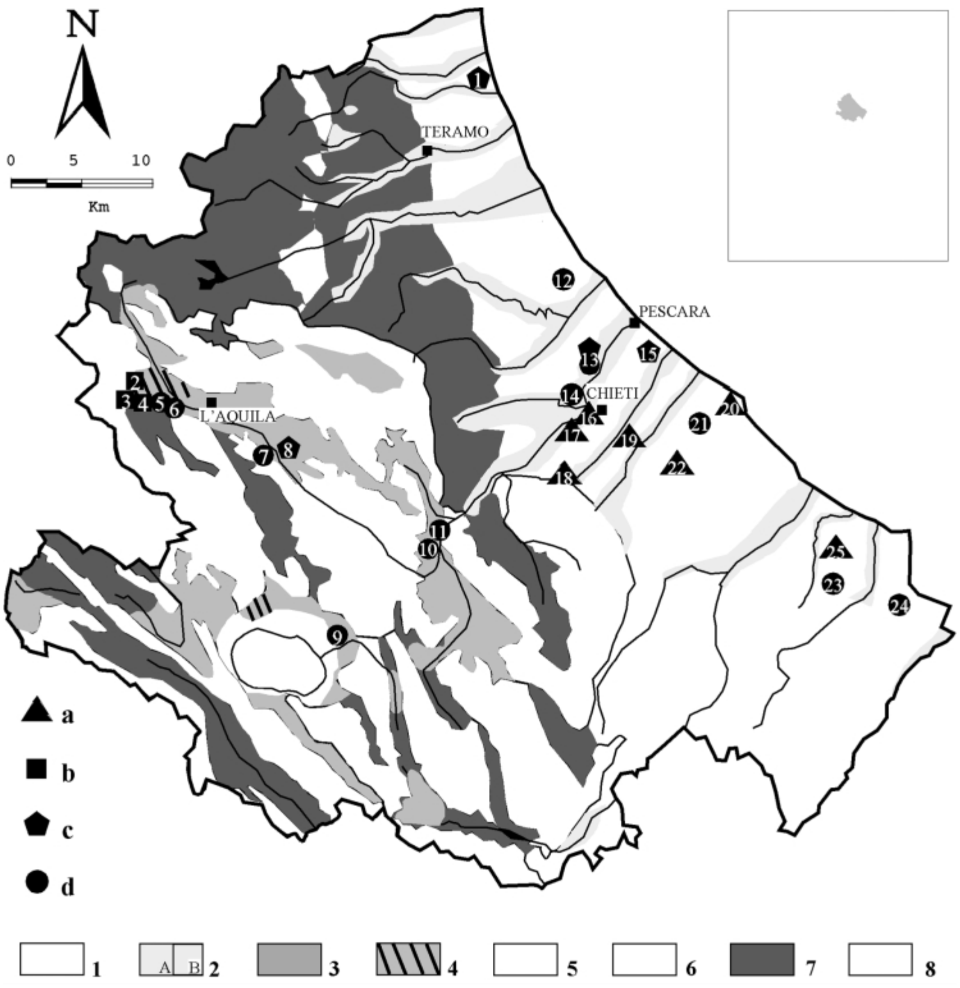

Fig.1 - Proboscidean-bearing sites:
a= Mammuthus (A.) meridionalis; b= Mammuthus (A.) meridionalis vestinus; c= Mammuthus (M.) trogontherii; d= Elephas (P.) antiquus; 1 - Tortoreto - Colle Badetta (TE); 2 - Scoppito - Madonna della Strada (AQ); 3 - Colle Mancino (AQ); 4 - Rocca S.Stefano (AQ); 5 - Pagliara di Sassa (AQ); 6 - Pagliara di Sassa (AQ); 7 - S.Eusanio Forconese (AQ); 8 - S.Demetrio dei Vestini (AQ); 9 - Pescina (AQ); 10 - Pratola Peligna (AQ); 11 - Popoli (PE); 12 - Città Sant'Angelo (PE) 13 - Villanova (PE); 14 - Cepagatti - Fiume Nora (PE); 15 - Francavilla al mare - Colline Villanesi (CH); 16 - Chieti -Località Civitella (CH); 17 - Chieti - località Brecciarola (CH); 18 - Serramonacesca - Castel Menardo (PE); 19 - Villamagna - Pian di Mare(CH); 20 - Ortona - Punta Ferruccio (CH); 21 - Tollo - Colle Secco (CH); 22 - Giuliano Teatino - Contrada "Tratturo" (CH); 23 - Scerni – località Torrione (CH); 24 - Vasto - Contrada della Lebba (CH); 25 - Villalfonsina (CH).
Geological scheme:
1-Deposits of lacustrine and fluvial environment of Fucino basin (Upper Pleistocene-Holocene); 2A–Deposits of fluvial environment; 2B–Coalescent deposits of flood plains environment and fan delta (Middle/Upper Pleistocene–Holocene); 3–Deposits of lacustrine and fluvial environment (Early/Upper Pleistocene–Holocene); 4–Deposits of lacustrine and fluvial environment (Upper Pliocene–Early Pleistocene); 5–Deposits of shore and fan delta environment and hemipelagic sediments (Middle Pliocene –Early Pleistocene); 6– "Molise Allochthonous": carbonatic and siliciclastic (turbitides) sequence (Upper Cretaceous–Upper Miocene); 7–Foredeep siliciclastic (turbitides) sequence (Middle Miocene-Early Pliocene); 8–Platform and basin sequence (Upper Triassic-Upper Miocene).

(Maccagno 1958), and near Rocca Santo Stefano and Colle Mancino (Mammuthus (A.) meridionalis vestinus) (Maccagno 1965). Still others were found in Middle Pleistocene (late Galerian of the mammalian biochronologic scale of Italy) sandstones and clays of the same alluvial delta fan, in two separate sites near Pagliare di Sassa (*Elephas (P.) antiquus*) (Maini 1952; Agostini *et al.* 1999; Palombo *et al.* 2001); other more were recovered in the Fossa–S.Demetrio valley again in the L'Aquila area, in gravels with sands and clay in the Middle/Upper Pleistocene terraced alluvial deposits of the "Formazione di San Marco" (Bertini & Bosi 1998) near S. Eusanio Forconese, (*Elephas (P.) antiquus*) (Maini 1952) and near San Demetrio dei Vestini on the left bank of the River Aterno (*Mammuthus (A.) meridionalis* after D'Erasmo (1931), perhaps actually *Mammuthus (M.) trogontherii*). Near Pratola Peligna, in the Sulmona basin, an elephant skull was found in marshy clays with lenses of gravel and sands dating from the end of the Mid-Pleistocene (*Elephas (P.) antiquus*), (Soprintendeza Archeologica dell'Abruzzo, unpublished data = S.A.A.) while some isolated teeth have been discovered in the same alluvial unit near Popoli (Soprintendeza Archeologica dell'Abruzzo, unpublished data = S.A.A.).

In the Fucino basin elephant remains (*Elephas (P.) antiquus*) (S.A.A.) were found during exploitation in a now disused quarry, near Pescina, in the Mid-Pleistocene alluvial beds.

The geological contexts of the elephant-bearing sites at the foot of the Abruzzo Apennines, on the slopes towards the Adriatic, are more complex. They can be divided into four types, as follows:

1. Fan deltas and lagoon facies, marking the end of the marine sequences, occur within the local early Mid–Pleistocene interval. These facies outcrop in the site of Civitella in Chieti (*Mammuthus (A.) meridionalis*), dating from the end of the Early Pleistocene (D'Erasmo 1931); in Giuliano Teatino (*Mammuthus (A.) meridionalis*) (Leuci & Scorziello 1993), dating from the latest part of the Early Pleistocene-Middle Pleistocene?; in the Mid-Pleistocene Colle Badetta site in Tortoreto (*Mammuthus (M.) trogontherii*) (S.A.A.); in the Middle Pleistocene locality of Pian di Mare near Villamagna (*Mammuthus (A.) meridionalis*) (S.A.A.); in Middle Pleistocene gravels uncovered during works for the railway tunnel at Punta Ferruccio, near Ortona (*Mammuthus (A.) meridionalis*) (D'Erasmo, 1931); and in the Early Pleistocene Villalfonsina area (*Mammuthus (A.) meridionalis*) (S.A.A).

2. Alluvial gravels overlying the above mentioned fan delta conglomerates, separated from these by an erosional surface and by a paleosoil preserved only in the lowest beds. This facies is present in the early Middle Pleistocene Colline Villanesi area at Francavilla al Mare (*Mammuthus (A.) meridionalis* after D'Erasmo (1931), perhaps actually *Mammuthus (M.) trogontherii*), in the Torrione area at Scerni (*Elephas (P.) antiquus*) (S.A.A.) and in the Colle Secco area at Tollo (*Elephas (P.) antiquus*) (S.A.A.) both dated to the Mid-Pleistocene, and in the upper Middle Pleistocene in Città Sant'Angelo site (*Elephas (P.) antiquus*) (S.A.A.).

3. In terraced alluvial deposits at the valley bottoms; over isolated sixty teeth have been recovered from the Middle Pleistocene terraced alluvial gravels in the River Pescara near Villanova (*Elephas (P.) antiquus* and *Mammuthus (M.) trogontherii*) (S.A.A.) and other findings come from the late Middle Pleistocene terraced alluvial units in Brecciarola, near Chieti (*Elephas (P.) antiquus*) (Radmilli 1977) and in the river Nora bed near Cepagatti (*Elephas (P.) antiquus*) (S.A.A.).

4. Talus fans at the foot of the mountain range; terraced coalescent deposits of alluvial plain making transition to delta fans. These talus fans consist of slightly elaborated breccias passing laterally to alluvial plain sands and clays dated to the Early Pleistocene, outcropping in Castelmenardo near Serramonacesca on the eastern slopes of the Majella mountain (*Mammuthus (A.) meridionalis*) (D'Erasmo 1931); alluvial plain gravels and sands passing to fan delta deposits dated to the late Middle Pleistocene yielded various other findings in

the areas of Contrada della Lebba and Punta della Lotta near Vasto (*Elephas (P.) antiquus*) (S.A.A.).

3. CONCLUSIONS

The sites known to date and reported here amount to a total of 25, spread both inside the chain of the Apennines and between the foot of the mountains and the present-day Adriatic coastline.

There are examples of *Mammuthus (A.) meridionalis* including both typical and advanced representatives among which the only findings that can be surely ascribed to *Mammuthus (A.) meridionalis vestinus* are those discovered in the surroundings of Madonna della Strada. Sometimes *Mammuthus (M.) trogontherii* and *Elephas antiquus* co-occur. The latter characterizes many alluvial deposits outcropping in the valley bottoms. Interestingly, the sites with prehistoric elephant remains are not only numerous but embrace a wide stratigraphic range and are related to different paleogeographic and environmental contexts. The proboscidean specimens represented at times solely by tusks or teeth, are sometimes accompanied to remains of other mammals and invertebrates. Some sites can therefore be supposed to correlate with the mammalian ages of the Plio-Pleistocene of Italy. No elephant remains have ever been found associated with prehistoric implements. Nevertheless a number of Palaeolithic sites have recently been discovered not far from elephant-bearing localities and in beds stratigraphically equivalent. For this reason a geologic and stratigraphical consistency of both cannot be thoroughly ruled out.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

Agostini, S., Manni, R., Massoli Novelli, R., Palombo, M. & Speranza, F. 1999. Il giacimento a vertebrati delle Pagliare di Sassa (L'Aquila). *Geoitalia, 2° Forum Fist* 1: 23-26.

Bosi, C. & Bertini, T. 1970. Geologia della media Valle dell'Aterno. *Mem. Soc. Geol. It.* 9: 719 -777.

Bertini, T. & Bosi, C. 1993. La tettonica quaternaria della conca di Fossa (L'Aquila), *Il Quaternario* 6: 293-314.

D'Erasmo, G. 1931. *L'Elephas meridionalis* nell'Abruzzo e nella Lucania. *Atti R. Acc. Sc. Fis. e Mat. Napoli* 18: 1-26.

Maccagno, A.M. 1958. Relazione sulla tecnica di scavo, restauro e montaggio dell'elefante fossile rinvenuto presso l'Aquila. *Ann. Ist. alta Cultura Aquila* 2: 1-14.

Maccagno, A.M. 1962. L'Elephas meridionalis Nesti di Contrada "Madonna della Strada" Scoppito (L'Aquila). *Atti Acc. Sc. Fis. e Nat. Napoli* 4: 1-129.

Maccagno, A.M. 1965. Nuovi ritrovamenti di resti elefantini nel Villafranchiano della Conca aquilana. *Boll. Soc. Nat. Napoli* 74: 1-22.

Maini, P.S. 1952. Su alcuni resti di mammiferi quaternari rinvenuti a Pagliara di Sassa e Cese di Preturo (altipiano aquilano). *Ann. Ist. Sup. Sc. e Let. S.Chiara Napoli* 4: 2-14

Maini, D. 1956. Sopra una zanna di *Elephas antiquus Italicus* rinvenuta a S.Eusanio Forconese (altipiano aquilano). *Ann. Ist. Sup. Sc. e Let. S.Chiara Napoli* 6: 2-12.

Leuci, G. & Scorziello, R. 1993. Il *Mammuthus meridionalis* (Nesti) di contrada "Tratturo" Giuliano Teatino (Chieti). *Boll. Mus. Reg. Sci. Nat. Torino* 11: 387-406.

Palombo *et alii* 2001. Middle Pleistocene faunas and lithic implements from Pagliare di Sassa (L'Aquila, Central Italy). *This volume.*

Radmilli, A.M. 1977. *Storia dell'Abruzzo dalle origini all'età del bronzo*. Pisa: Giardini Editori e Stampatori.

The fauna of La Polledrara di Cecanibbio and Rebibbia-Casal de’ Pazzi (Rome, Italy) as an indicator for site formation processes in a fluvial environment

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SUMMARY: This paper presents the preliminary results of the study of the fracture patterns and of the state of preservation of bone surfaces of the paleontological remains from the Middle Pleistocene sites of La Polledrara di Cecanibbio and Rebibbia-Casal de’ Pazzi. In any case, the sampled data, although partial, are sufficiently representative for the analysis of the formation modes of the two bone assemblages, both deposited in a fluvial environment.

1. CONTEXT

The site of La Polledrara is located about 20 km NW of Rome, and it can be included within the Aurelia Formation, correlated with the OIS 9. The deposit is associated with an ancient river bed of a small water channel, incised in a compact tufite bank, that was investigated together with parts of its edges over an area of more than 750 square meters.

The archaeological excavation started in 1985 and is still continuing. The abundant paleontological material, over 9000 specimens, mainly referable to *Elephas (Palaeoloxodon) antiquus, Bos primigenius, Cervus elaphus, Equus ferus* ssp., was transported by a low energy stream and deposited at the bottom of the river bed and close to the edges. Lithic industry, made from small flint pebbles and tools made from long bone shaft fragments of elephant was associated to the faunal assemblage. Later ashy tufite sediments, containing rare bone fragments, covered the fluvial channel originating an environment characterized by stagnant water that allowed the preservation of *Elephas* and *Canis lupus* portions still in anatomical connection.

The site of Rebibbia-Casal de’ Pazzi is located in the lower Aniene river valley within the suburban area of Rome. It is considered part of the sedimentary cycle of the Vitinia Formation, chronologically correlated to the OIS 7. The archaeological excavations, carried out between 1981 and 1986, covered an extension of about 1200 square meters. A portion of the ancient river bed incised in a bank of “Tufo litoide lionato” as well as the left edge have been exposed. The strata filling the river bed, composed of gravel and sands of pyroclastic origin, yielded over 2000 faunal remains mostly referable to *Elephas (Palaeoloxodon) antiquus, Bos primigenius, Cervus elaphus, Equus ferus*, associates with abundant lithic industry. Both lithic and faunal materials were concentrated in the levels with gravels, formed during the first phase of the river bed filling, characterized by a high energy fluvial stream. Such fluvial regimen was sufficiently strong to determine, in the flooding phases, the erosion of the older formations present in the marginal areas, also upstream of the deposit. In some of these formations there were probably some lithic and faunal materials that, as a consequence of these erosional events, were transported to the river bed. This produced a mixture of old materials with more recent specimens referable to the animal and anthropic biosphere of the territory surrounding the river.

This association of lithic and faunal materials referable to different chronological phases is the main feature differentiating the site of Rebibbia-Casal de' Pazzi from that of La Polledrara di Cecanibbio where the different phases of deposition accumulated chronologically homogeneous materials.

2. METHODS

Several parameters have been taken into account in order to investigate the features of the two bone assemblages. Such parameters are related to the natural or anthropic actions experienced by each specimen before, during and after the formation of the deposits: spatial coordinates, taxonomy and anatomy (species and age at death, skeletal element, preserved portion and segment, side), dimensions of the specimen (length, width, thickness), portion of preserved diaphysis (percentage of circumference and length), state of preservation of the specimen and of its surfaces (rolling, erosion, abrasion, abrasion striae, chipping, Behrensmeyer's stage, type of fossilization and color, presence of concretions), type of fracture on proximal and distal ends (shape and angle, possible modifications and removals produced by use), presence of lateral impacts due to direct percussion and/or produced by the anvil, category where the fracture typologies of the specimen should be placed. This research continues the formulation already applied in the preliminary studies carried out in collaboration with Paola Villa (Anzidei *et al.* 1995; Villa *et al.* 1999), following Gifford & Crader (1977).

Such parameterization of the taxonomic, anatomical and morphological attributes of the specimens allowed the definition of categories, synthesizing the events experienced by the bones from the death of the animal to their discovery during the excavation.

The analysis of the parameters relative to the state of preservation of the specimens and of the surfaces allows us to define, with a statistical meaning, duration of exposure of the bones before burial and the extent and mode of transport, as well as the spatial and temporal homogeneity of the provenience of the skeletal elements.

The aim of the analysis of fracture attributes is to define, always at a statistical level, which specimens had only natural displacement, a possible transport before the final burial, with fractures produced by sediment pressure; or which remains were fractured when the bone was still fresh, both because of natural events (e.g., impacts during fluvial transport, trampling) and human activity (fracturing for marrow extraction), but the causes cannot be always ascertained.

In few cases it was possible to recognize intentional anthropic action with the production of bone tool using the same modes of lithic technology.

Tab.1 - Categories.

0 – bones with modern damages
1 – complete bones
2 – complete bones with natural damages
3 – fragments with post-depositional fractures
4 – bones with post-depositional fractures or modifications of uncertain origin
5 – bones with fresh bone fractures without other attributes
6 – bones with evident percussion marks, cause of the fracture
7 – bones with natural or uncertain removals, larger than the chipping
8 – bones with fresh bone fractures and possible intentional removals, possibly with functional form
9 – flakes of type 8
5/7 – intermediate category
7/8 - intermediate category

3. RESULTS

The sample analyzed is still too partial to approach a global taphonomic study of the two sites; however, it allow us to make some general observations. About 40% (NISP=777) of the faunal remains of the site of Casal de' Pazzi have been analyzed and the specimens come from all the levels of the river bed filling. In the case of La Polledrara about 10% (NISP=881) of the specimens, coming from different zones of the paleosurface, have been studied. This sample, although partial, can be considered sufficiently representative for the identification of the distinctive features of the assemblage in relation to the presence of the different species and to the type of agents modifying the faunal remains.

In both sites *Elephas antiquus* and *Bos primigenius* (plus *Bos* vel *Bison*) are the most frequent species; the study focused only smaller specimens leaving aside, for the moment, the largest complete bones such as for example elephant vertebrae, ribs, pelvises, femurs, and tusks.

It has been possible an attribution to species or at least genus for 60.4% of the specimens analyzed at La Polledrara and for 39.9% of those from Casal de' Pazzi. A generic attribution to wider categories (large or small herbivores) was possible for 30.5% of the specimens in the first site and 51.6% in the second one. The remaining materials, mainly flakes, often rolled (9.1% at La Polledrara and 8.5% at Casal de' Pazzi), did not allow any taxonomic attribution.

Most of the specimens analyzed are fragmented long bones; whole specimens are usually only teeth carpals, tarsals and phalanges. However, from the qualitative analysis of the whole assemblages it is possible to observe that at La Polledrara the number of complete long bones is higher than in the other site.

In the samples there are only few data relative to the age at death of the individuals. At Casal de' Pazzi 651 (83.8%) out of 777 remains do not provide indication of age, while 117 (15.0%) are referable to adults, the remaining 9 (1.2%) belong to young individuals. At La Polledrara, 720 (81.7%) out of 881 specimens, do not provide indication of age at death, 135 (15.3%) are adults, while the remaining 26 (3%) are referable to young animals.

Passing to the analysis of the alteration state of the surfaces, the percentages of rolling and erosion in the two deposits have been compared. In table 2 it is possible to observe that, while at La Polledrara rolling tend to be higher than at Casal de' Pazzi, the opposite is true for the erosion. However, it should be noted that often at Casal de' Pazzi the strong erosion does not allow to decipher the degree of rolling; in fact in this site there are evident surface alterations produced by more intense chemical attacks and by root action.

Tab.2 - Degrees of rolling and erosion (%) (following Gifford & Crader 1977).

Degrees	**La Polledrara**		**Casal de' Pazzi**	
	roll.	**eros.**	**roll.**	**eros.**
0	9.2	29.9	13.3	17.4
0-1	7.8	14.0	12.1	11.7
1	35.3	36.9	32.4	32.0
1-2	16.9	2.0	16.7	10.6
2-1	0.3	0.1	8.0	0.1
2	26.0	5.4	12.4	10.1
2-3	0.1		0.3	1.7
3	0.9	0.3		3.1
3-4				0.1
4				1.4
other	3.6	11.2	4.9	11.7
Total	100.0	100.0	100.0	100.0

In both sites, but with a clear prevalence at Casal de' Pazzi, it is possible to detect different degrees of rolling and/or erosion on the same specimen (intermediate categories and "other", in table 2). Such variability on the surface of the same element can be explained by its presence in a fluvial environment, where its displacement in different stages may have produced its partial burial and consequent partial exposure of the surfaces to natural agents.

As regards the type of fracture of bone remains, the analysis has been performed on the basis of the study by Villa & Mahieu (1991).

Fracture pattern has been therefore verified on distal and proximal ends of the long bones, with a distinction into two groups in relation to the main axis of the bone: curve (spiral), V shaped (pointed and negative), transverse, oblique, and stepped. The angle between the fracture and the external surface of the bone has been defined as oblique or right, with a further indication of the aspect of the surface as smooth or jagged. Furthermore also the degree of bone fragmentation has been recorded considering the length and circumference of the preserved shaft. On the basis of the sum of the parameters considered for each specimen, this has been placed into a specific category. The categories considered (a total of nine) are reported in tables 1 and 3.

4. CONCLUSION

From the analysis of the data reported in the table it is possible to make the following observations.

As regards the categories relative to complete bones, those with natural damages or those with natural and post depositional fractures (Categories 1-4), at La Polledrara complete bones or specimens with natural damages are more frequent (1, 2); while at Casal de' Pazzi those with post-depositional fractures or fractures of uncertain origin are prevalent (3, 4). As regards the categories relative to bones with fresh bone fractures, at Casal de' Pazzi those on fresh bone without other attributes are prevalent (5), but bones with percussion marks, almost absent at this site, are instead well represented at La Polledrara. However, it should be mentioned that the sample examined does not include the bone tool identified in the two sites (Anzidei & Ruffo 1985; Anzidei *et al.* 1999). As already evidenced by Villa *et al.* 1999, although it is known from the literature that hyenas are able to fracture bones of large herbivores producing morphological features of the fractures that could be confused with those produced by human activities, it should be considered that categories 8 and 9 at La Polledrara, include large sized long bone shaft fragments of elephant with butt and percussion

Tab.3 - Frequency of fracture categories.

Cat	**La Polledrara di Cecanibbio**						**Rebibbia-Casal de' Pazzi**					
	Gerb	**Perb**	**Bov**	**Cerv**	**El**	**Total**	**Gerb**	**Perb**	**Bov**	**Cerv**	**El**	**Total**
0	0.4	7.7	3.8	10.5	2.2	2.5	2.3	2.0	1.8	2.3	1.4	2.0
1	0.8		13.8	10.5	6.1	7.5		1.0	6.3	2.3		1.3
2	1.2		11.9	5.3	4.4	6.4			17.0	4.5	6.3	4.3
3	18.0	15.4	19.8	42.1	25.0	20.9	17.7	16.7	39.3	29.5	58.5	30.0
4	40.0	76.9	30.5	26.3	30.0	34.1	45.5	50.0	20.5	38.6	24.6	37.5
5	34.1		13.5	5.3	13.9	19.9	34.4	30.4	14.3	22.7	9.2	24.7
6	1.6		1.3		1.1	1.3						
7	2.0		0.9		5.0	2.2						
8	0.4		2.2		4.4	2.0			0.9			0.1
9	1.6				6.1	1.9						
5/7			0.6		0.6	0.4						
7/8			1.6		1.1	0.9						
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(Cat: category; Gerb: large herbivores; Perb: small herbivores; Bov: *Bos primigenius, Bos* vel *Bison*; Cerv: *Cervus elaphus, Dama* sp., Cervidae indet.; El: *Elephas antiquus*).

bulb. These large flakes are not eroded or rolled and they do not show evidence of carnivore gnaw marks. Furthermore, the same categories include also metapodial distal and proximal ends as well as radii of large bovids with several unidirectional removals on the external and internal faces subsequent to the primary fracture. Therefore, the presence at La Polledrara of bones with probable traces of utilization and modification, could be a reliable evidence for human presence with exploitation of animal resources. In contrast, at Casal de' Pazzi these evidences are much more rare, probably also for the disturbance produced by a fluvial current with a higher energy compared to that of La Polledrara.

5. REFERENCES

Anzidei, A.P. & Ruffo, M. 1985. The Pleistocene deposit of Rebibbia-Casal de' Pazzi (Rome, Italy). *Papers in Italian Archaeology IV - Part I. The Human Landscape. BAR International Series* 243: 69-85. Oxford.

Anzidei, A.P., Villa, P. & Cerilli, E. 1995. La Polledrara di Cecanibbio (Roma). Dati preliminari sull'analisi tafonomica dei reperti faunistici. *Atti del Secondo Incontro di Studi di Preistoria e Protostoria in Etruria* (*Farnese, VT, 21-23 maggio 1993*).

Anzidei, A.P., Arnoldus Huyzendveld, A., Lemorini, C. Caloi, L. & Palombo, M.R. 1999. Two Middle Pleistocene sites near Rome (Italy): la Polledrara di Cecanibbio and Rebibbia-Casal de' Pazzi. *The role of early humans in the accumulation of European Lower and Middle Paleolithic bone assemblages*, *Monographien des Römisch-Germanischen Zentralmuseums* 42*:*173-195. Mainz.

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Mussi, M. & Palombo, M.R., in press. Nouvelles données sur le gisement Pleistocène moyen de La Polledrara di Cecanibbio (Latium, Italie). *Actes du Colloque International de Tautavel sur "Les Premiers habitants de l'Europe" (10-15 avril 2000).*

Bonnichsen, R. & Sorg, M.H. (eds.) 1989. *Bone Modification*. Center for the study of the first Americans, Orono, Maine.

Behrensmeyer, A.K. 1978. Taphonomic and ecologic information from bone weathering. *Paleobiology* 4: 150-162.

Gifford, D.P. & Crader, D.C. 1977. A computer coding system for archaeological faunal remains. *American Antiquity* 42 :225-238.

Haynes, G. 1991. *Mammoths, Mastodonts & Elephants. Biology, behavior and the fossil record*. Cambridge: Cambridge University Press.

Lyman, R. 1994. *Vertebrate taphonomy*. Cambridge: Cambridge University Press.

Tagliacozzo, A., Cassoli, P.F., Curci, A. & Fiore, I. 1999. Analisi tafonomica dei resti ossei del livello Alfa. In Piperno, M. (ed.), *Notarchirico. Un sito del Pleistocene medio iniziale nel bacino di Venosa:* 455-534. Venosa: Osanna.

Villa, P., Anzidei, A.P. & Cerilli, E. 1999. Bones and bone modifications at La Polledrara, a Middle Pleistocene site in Italy. *The role of early humans in the accumulation of European Lower and Middle Palaeolithic bone assemblages*, *Monographien des Römisch-Germanischen Zentralmuseums* 42: 197-206. Mainz.

Villa, P & Mahieu, E. 1991. Breakage patterns in human long bones. *Journal of Human Evolution* 21: 27-38.

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Elephants from the delta of paleo-Don river

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SUMMARY: Two skeletons of the steppe mammoth *Mammuthus trogontherii* are discussed in this paper. The skeletons were excavated in 1964 and 1999 in the Azov region (Russia) and are of Middle Pleistocene age. Comparisons are made with *Archidiskodon tamanensis* from Siniaya Balka and *Mammithus trogontherii* from Mosbach and Süssenborn.

The delta of Don inherits the valley of an ancestor river and its banks are rich with well-known locations of elephants remains and other Plio-Pleistocene vertebrates. The excavations of two skeletons of steppe elephant on the left delta bank near Azov city (1964 and 1999) became quite an event for palaeontologists. The first skeleton (Tr-1) was assembled and exhibited in the Azov Local Museum. The digging-out of the second skeleton (Tr-2) was performed by collaborators of Azov Museum with the participation of geologists P. Haesaerts and A.E. Dodonov. Micromammals were collected by V.V. Titov and identified by A.S. Tesakov. The author is very grateful to the scientists mentioned above.

The arrangement of bones indicates that the animals were buried in the sites of their death (Fig. 1). Entire M^3 were found in the skulls. This enabled us to study all the parameters of the crowns and compare them with serial teeth collections from Syniaya Balka, Mosbach III and Süssenborn according to A. Lister (1996, fig. 19,4) and W. Guenther (1969, abb. 4). The mean thickness of enamel of M^3 of Azov elephant is 3,2 and 2,93 mm and lamellar frequency is 5,5 and 6 which is most similar to the mean parameters M^3 of *Archidiskodon tamanensis*. The hypsodonty indexes (1,8 and 1,83 for Tr-1; 1,8, 1,7, 1,73 for Tr-2) were similar to indexes of 10 teeth of *Mammuthus trogontherii* from Mosbach III. This suggests a relationship with *Mammuthus trogontherii* from Azov and *Archidiskodon tamanensis* and similarity with the steppe elephant from Germany. The other figure shows the correlation between the length and plate number for M^3 of the elephant from Süssenborn. The teeth of Tr-1 and Tr-2 correspond to extremely high values and even exceed the levels of the elephant from Germany. Figure 2 shows the concurrence of the parameters mentioned above for the elephant from Azov with those for *M. trogontherii* from Tiraspol (Dubrovo, 1971), which was described by M. Pavlow (1910) as "*Elephas wusti*". This may be considered as the evidence of subspecies status of the elephant from Azov.

Deposits with *M. trogontherii* are underlined by strata with an early Tiraspol rodent association (*Lagurus transiens*, *Microtus gregaloides*). Similar rests were noted near Semibalki I village (Rekovets 1994) and also identified as *Microtus-Lagurus* association indicating temperature decrease and the presence of a mesophyl steppe. Mollusc fauna from Kagalnik sandpit with Tr-2 (identification by A.L. Chepalyga) helps to correlate these lays with early Tiraspol, which is confirmed by the normal polarity of rocks and their attitude to the Brunhes zone (identification by V.M. Trubikhin).

The skull of Tr-2 was partly destroyed after death before burying. There were taken 21 measurements from it. The condylobasale length of the skull Tr-2 was smaller (115.0 cm) than the same of Tr - 1 (144.0 cm).

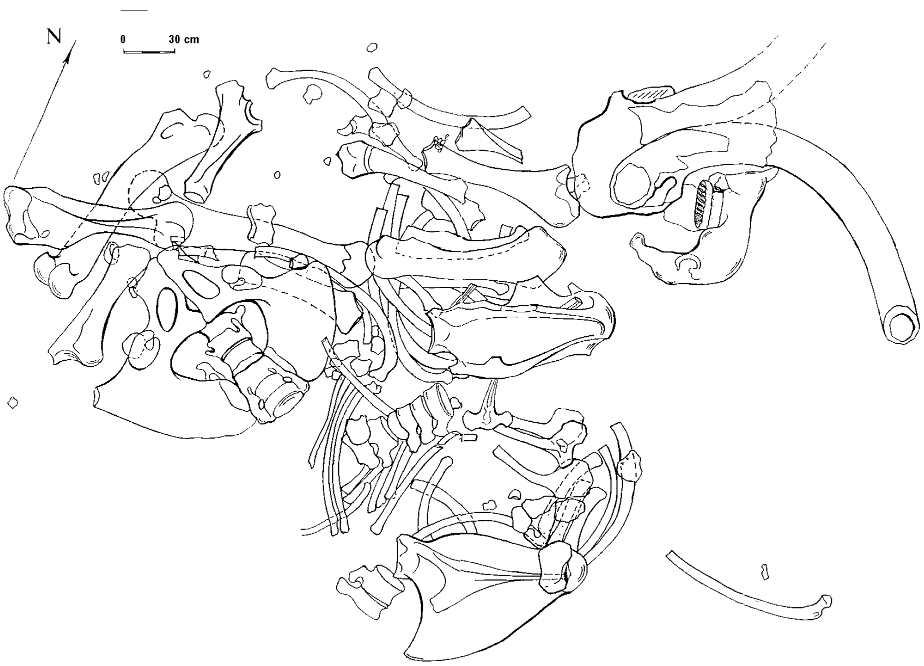

Fig.1 - The position of *Mammuthus trogontherii* (Tr-2) skeleton during the 1999 excavations.

The long bones of Tr-2 are more thin - ratio of diaphysis width to humerus length is 11.72; for ulna is 11.27; for femur is 12.4; for tibia is 14.1. The measurements of pelvis were performed using the method of A. Lister (1996). Ratio between pelvic aperture height and ilium shaft width (measurements 2:5) is 3.28, and ratio between pelvic aperture width and ilium shaft width (measurements 3:5) is 2.65 and 2.78. This indicates that the Tr-2 skeleton is likely to be a female one. The height of Tr-1 is 4.5 m, Tr-2 is nearly 4 m that is rather significant and similar to that of the skeleton from Nogaisk (4.1 m) and Georgievsk (4 m). The rests of Tr-2 are located in the funds of the Azov Museum and must be restored.

Both Azov elephants have serial structure of the carpals. Proportions between the weight of os lunatum and the weight of os magnum is 78.3 grams for Tr-1 and 89.78 for Tr-2; the proportions of the difference of that bones to the weight of os lunatum are 21.7 and 10.21 accordingly. This is typical for serial type of *Archidiskodon* carpal bones and differs from the aserial type of *Mammuthus* (Dubrovo & Jakubowski 1989). Very likely *M. trogontherii* from Azov retained the serial type of carpals as in another ancient elephants from Nogaisk and Stavropol.

A decreased form of *M. trogontherii* was found in the delta of the Don river near Taganrog. This is a fragment of a skull with M^2M^3 sin and dex (EI-234). The teeth resemble those from Süssenborn. The crown length is 240.0 mm, the width is 84.0 mm, and the height of the entire lamina is 180.0 mm, lamellar frequency is 6.25 and 6.0, mean thickness of enamel is 2.08 and 2.02. The plate number (t14) corresponds to that of M^3 of the skeleton from Edersleben (Germany). We supposed it to be a decreased form of *M. trogontherii* also.

An interesting collection of *A. tamanensis* from Port-Katon village and Semibalki 3 (layers 4-5) is represented in Azov museum. Geologists and palaeontologists studied both locations in detail. Micro- and macromammals of Taman faunal Unit were found here (Bajgusheva 2000).

The collection of the elephant *A. gromovi* remains from the right bank of the Don delta (Liventsovka, Khapry and others) is well known.

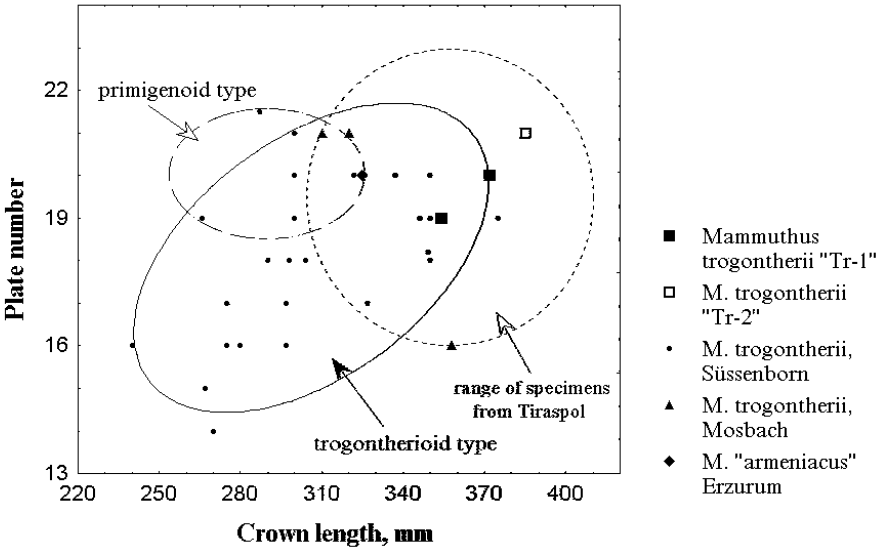

Fig.2 - Ratio between crown length and plate number in upper M3 of some *M. trogontherii*: Tr-1 - *M. trogontherii* from Azov, 1964; Tr-2 - *M. trogontherii* from Azov, 1999; *M. trogontherii* from Süssenborn by W. Guenther 1969; the data of *M. trogontherii* from Tiraspol by Dubrovo, 1971 (upper and lower M3 together); the data of *M. "armeniacus"* by Adam 1988. "Primigenoid and trogontherioid types"by W. Guenther 1969.

Some elephant teeth were found in the bay near Taganrog city. Two of them M^3 (EI-59) and M$_3$ (EI-112) are significantly abraded. The lamellar frequency is 8.5 and 7.5; the thickness of enamel is 1.8 and 2.03. We consider them to be a Post-Khazar M. primigenius similar to the elephant from Kamensk (Bajgusheva 1980, 1999). Last ones lived during the formation of Roslavl-Moscow horizon of Pleistocene, according to I.V. Foronova and A.N. Zudin (1995). Three other teeth M^3 (EI-5, EI-10) and M$_3$ (EI-7) have antiquoid figure of abrasion. The functional density of plates on M^3 is 4.7 and 5.5; relative hypsodonty is 3.2 and 3.0. This allows to determinate those findings as *Palaeoloxodon* cf. *antiquus*. It differs from P. antiquus (Aguire 1969) by a longer crown of M^3 (350 and 300 mm); M$_3$ (345 mm); the plate number - 17 and 18 (excluding talons); the ratio between crown height and M^3 length - 91.42 and 96.7. This may be connected with more severe environment of the south of Eastern Europe. Probably these three teeth belong to a new subspecies of the forest elephant.

REFERENCES

Adam, K.D. 1988. Uber pleistozane Elephanten-Funde im Umland von Erzurum in Ostanatolien. *Stuttgarter Beitr. Naturk.* 146: 1-89.

Aguirre, E. 1969. Evolutionary history of the elephant. *Science* 164: 1366-1376.

Baigusheva, V.S. 1980. Mammoth (*Mammuthus primigenius* Blum.) of the left bank of the Siversky Donetz River. *Proc. Zool. Inst. Acad.Sci. USSR* 93: 75-80 (in Russian).

Baigusheva, V.S. 1999. About some paleontological finds from the collection of the Museum of Cossack history. *Kraevedcheskie zapiski* 4: 94-115 (in Russian).

Baigusheva, V.S. 2000. New data about Taman faunistical complex from the site near the village Semibalka (Azov region). *Historical and archeological researches in*

Azov and Lower Don 16: 27-57 (in Russian).

Dubrovo, I.A. 1971. Family Elephantidae Gray, 1821. *Pleistocene of Tiraspol*: 92-108 (in Russian).

Dubrovo, I.A., Yakubovski G. 1989. New data about genera characteristics of fossil elephants. *Bull. Com. Res. Quatern. Period* 58: 139-146 (in Russian).

Guenther, E.W. 1969. Die Elephantenmolaren aus den Kiesen von Süssenborn bei Weimar. *Paläont.* III: 711-731.

Lister, A. 1996. Evolution and taxonomy of Eurasian mammoths. In J. Shoshani & P. Tassy (eds.), *The Proboscidea: Evolution and paleontology of elephants and their relatives:* 202-213. Oxford: Oxford University Press.

Pavlov, M. 1910. *Les Éléphants fossiles de la Russie. Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou* 17: 1-57.

Rekovets, L.I. 1994. *Small mammals of the Anthropogene of the south of Eastern Europe*. Kiev: Naukova Dumka (in Russian).

The World of Elephants - International Congress, Rome 2001

The Early Palaeolithic butchery site of Barogali (Republic of Djibouti)

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SUMMARY: Three seasons of excavations (1985-1987) in the Gobaad region of the Republic of Djibouti led to the discovery of the fossilized skeletal remains of an *Elephas recki* (1,3-1,6 Ma old). Numerous stone artefacts discovered among the bones indicates that the excavation is a butchery site where hominids cut up and perhaps consumed the elephant meat. The discovery of cores and small flakes near the elephant carcass indicates that the hominids knapped choppers and polyhedrons and retouched flakes during the scavenging operation.

In Gobaad, in the west of the Republic of Djibouti, a few kilometres from the Ethiopian border near Lake Abhé, early faunal evidence lies beneath ancient swamp and river sediments.

At a spot known as Barogali the hardened and compacted sediments of a Pleistocene swamp can be seen in section below the layer of diatomite deposited by a Holocene lake. It was in the midst of the former that the skeletal remains of an elephant came to light, in the same context as some stone tools.

The palaeontological classification formulated by Cl. Guérin identified the remains as *Elephas recki ileretensis*, an elephant that disappeared between 1.3 and 1.2 million years ago (Chavaillon *et al.* 1987). The ESR dating of the elephant's lower third molar gave a date of between 1.6 and 1.3 Ma which would confirm its palaeontological grouping, as does the stone tool analysis (Berthelet 1999, 2001). The earlier date of 1.6 million years would provide us with a typical selection of Oldowan stone tools. On the other hand, despite the presence of a somewhat archaic industrial assemblage the later date of 1.3 million years would place the deposit in a Developed Oldowan or in an Early Acheulean context lacking some of the typical artefacts of this techno-complex.

The excavation peeled off the surface stratigraphy, enabling a detailed plan to be drawn of the elephant remains. The animal appeared to have been lying on its left side. Unlike the Haidalo elephant a few kilometres away, the Barogali skeletal remains were not in their anatomical position. Here the bones had been hacked and scattered apart. Various bones of the animal are missing; a fact that leads us to suppose that the river erosion noted in the northern sector had subsequently carried away some parts of the skeleton.

Whether the dead beast had been found as carrion or the animal fallen prey to hunters, the carcass had been stripped and torn to pieces. Some of the bones were still grouped in near-anatomical position, others separated and at times scattered apart. This would have been a hunting spot frequented by carnivorous animals and birds of prey as well as man.

The animal's skull was found shattered and out of its anatomical position in the southwest corner of the site. The cranial roof had been separated from the calvarium, almost certainly to get at the brain. The animal's tusks were still in place and anatomically connected to the upper jaw. However, various rib fragments lay between the two tusks and a vertebra by the point of the right one.

Fig.1 - General plan of the Barogali excavation (drawing by J.L. Boisaubert).

The jaws had apparently been broken apart to extract the tongue.

The lithic assemblage that came to light in the same context as the skeletal remains is important given that in order to strip the carcass it had been necessary to fashion tools from a mediocre volcanic rock which was to be found further to the south. 569 artefacts came to light: the lithic assemblage demonstrates a specialised tool production aimed at specific needs, such as scraping, chopping and shattering the bone. The hunters had carried blocks of lava with them into the swamp. Given that the amount of tool making debris makes up 65% of the whole the blocks must have worked as a kind of portable knapper's workshop set up next to the animal carcass.

There is a high number of percussion tools: five percussion blocks and over a hundred cobble fragments, more often with signs of multiple fractures.

Choppers make up almost a third of the number of pebble tools. Five different types of chopping-tool have been classified, most are side choppers, and all are bifacial tools.

Polyhedrons, spheroids and bolas, though infrequent, make up 22% of the pebble tools. This is a relatively higher proportion when compared with other non-butchery sites. The rounded shape of the Baragoli bola is similar to the one uncovered at Garba IV (M. Piperno, pers. com.), a Developed Oldowan A site in Melka Kunturé, Ethiopia. The heavy scrapers (31%) can be divided into two types, one with a broad edge and low sloping blade, and the other with a thick flat edge.

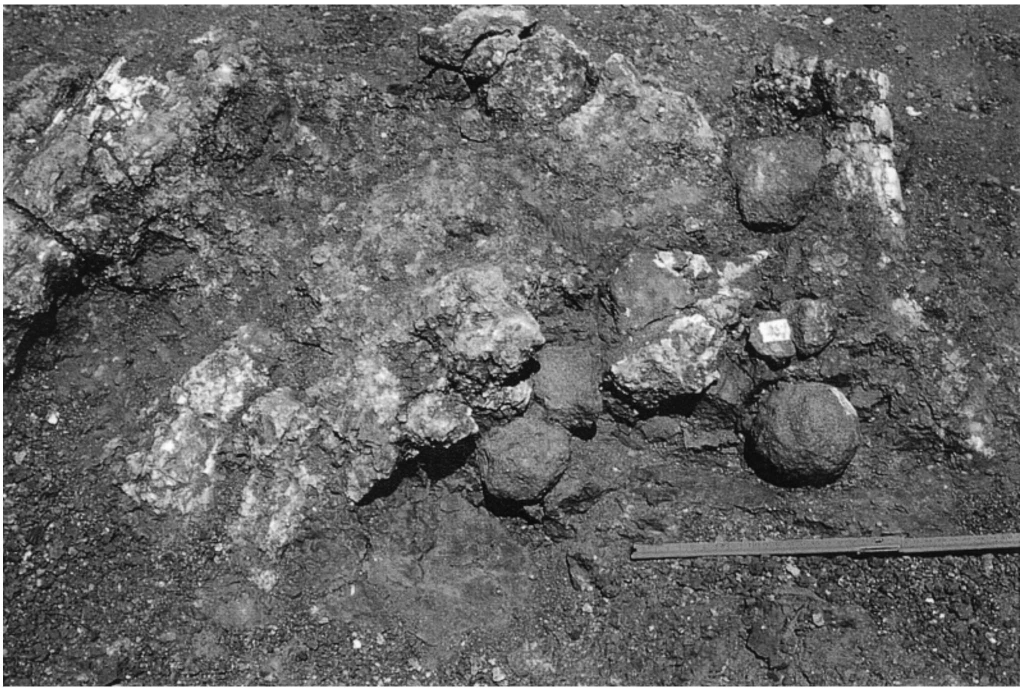

Fig.2 - Barogali. Detail of some pebbles tools and bolsa around the *Elephas recki* bones.

The “débitage” products come from both retouched pebbles and cores. The latter (14) divide into unipolar, centripetal or polyhedrical types.

There is a considerable amount of flake debris, with both entire (185) and broken (217) pieces, but only 36 actual flake tools. These include backed knives, notched and denticulated tools, but for the most part are lightly retouched blades.

The selection of stone tools was intended for precise purposes: stripping the animal, chopping up the meat, and scraping or shattering the bone.

The position of the stone artefacts around the carcass enables us to hypothesise as to the way of life of this hominids.

In East Africa there are a greater number of big mammal butchery sites. They have been identified in Olduvai Bed I and II (Tanzania), in Koobi Fora (Kenya), in both Melka Kunture (Gomboré II) and Hargufia (Ethiopia). The Barogali site is therefore recognised as part of this select group of rare Oldowan, Early and Middle Acheulean butchery sites.

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REFERENCES

Beden, M. 1980. *Elephas recki* Dietrich, 1915 (Proboscidea, Elephantidea): évolution au cours du Plio-Pleistocène en Afrique orientale. *Géobios* 13 (6): 891-901.

Berthelet, A. 1999. Le Paléolithique ancien en République de Djibouti, nouvelles prospections et fouilles (1985-1992), *Mémoire EPHE*, 1-2: 307-150.

Berthelet, A. 2001. L'outillage lithique du site de dépeçage à *Elephas recki ileretensis* de Barogali (République de Djibouti), *C.R. Acad. Sci. Paris* II, 332: 411-416.

Chavaillon, J., Berthelet, A., Boisaubert, J.L., Faure, M., Guérin, Cl., Warsama, S.A. 1987. Le site de dépeçage pléistocène à *Elephas recki* de Barogali, République de Djibouti. Nouveaux résultats et datations. *C. R. Acad. Sci. Paris* II, 305: 1259-1266.

Chavaillon, J., Berthelet, A., Boisaubert, J.L., Faure, M., Guérin,Cl., Warsama, S.A. 1990. Un *Elephas recki* découvert en connexion anatomique dans le site de Haïdalo, près de As Eyla (république de Djibouti), *C.R. Acad. Sci. Paris* II, 310: 441-446.

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Birds over the mammoths' head in Bulgaria

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SUMMARY: The Pleistocene avifaunas of Bulgaria remained poorly known until the early 1980-ies when a series of publications have appeared. Six disappeared species from the recent country's fauna have been established: *Lagopus mutus, L. lagopus, Tetrao tetrix, Phasianus colchicus* (native subspecies *colchicus* form), *Nyctea scandiaca* and *Pyrrhocorax pyrrhocorax*. One species (*Perdix palaeoperdix*) is fossil. The paper summarizes all data on the Pleistocene bird faunas of Bulgaria, based on 5770 avian bone fossils of 160 species from at least 18 localities (Tab. 2).

The Pleistocene avifaunas of Bulgaria are still poorly known. In contrast of Croatia, partly Serbia and Greece and most of the countries of Central and Western Europe, the Pleistocene bird faunas of Bulgaria remained completely unstudied until the early 1980-ies. Two foreign specialists have published their results for 2 Bulgarian sites – the Bacho Kiro Cave (Bochenski 1982) and the Karlukovo 4 Cave (Mlikovsky 1997). Among the results of the former study is the first occurrence of *Lagopus mutus,* a disappeared species in the recent Bulgarian avifauna. Later a series of publications appeared on the avian finds from the Pleistocene (mainly cave) deposits (see Tab. 1, Fig. 1).

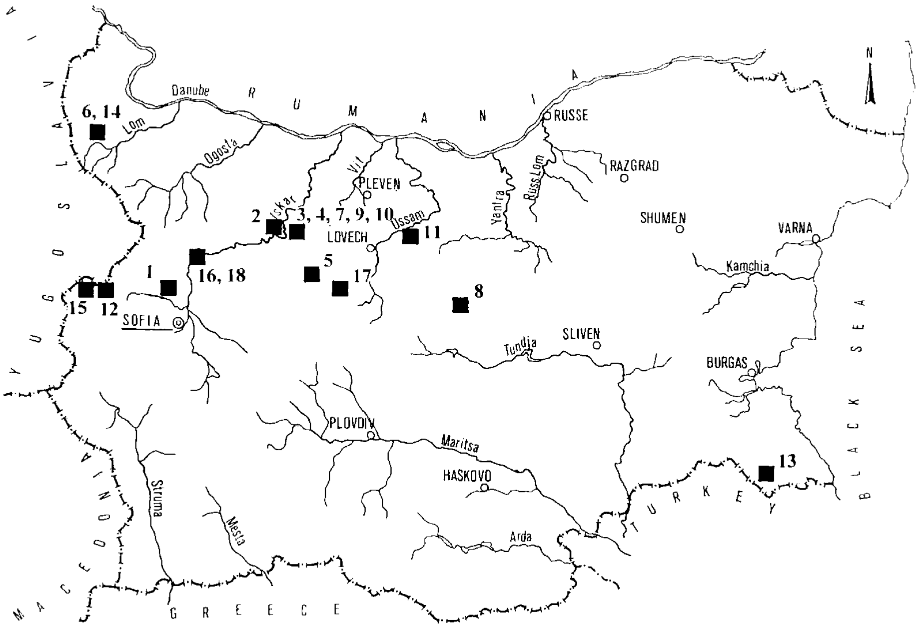

Fig.1 - Location of the Pleistocene avian sites of Bulgaria. Numeration as in the text.

Tab.1 - Chronostratigraphical and taxonomical distribution of the Pleistocene avian fossils of Bulgaria.

Subdivisions of Pleistocene	Sites	References (avian fauna)	Biochronostratigraphy	References (Biochronostratigraphy)	Number of avian taxa	Percentage of all Pleistocene avifauna
Late	18. Razhishkata Cave	Boev (2000 c)	Late Pleistocene - Holocene transition	Popov (in press)	39	24,38
	17. Toplya Cave	Boev (1999 a)	Wurm	V. Popov (unpubl data)	3	1,88
	16. Kozarskata Cave	Boev (in press - c)	Pleniglacial – 2	V. Popov (unpubl data)	5	3,13
	15. Tsareva Tsarkva Cave	Boev (in press - b)	Late Pleistocene	N. Spassov (unpubl data)	4	2,5
	14. Mirizlivka Cave	Boev (1999 a)	Late Pleistocene	Nikolov (1983), Popov (1983)	3	1,88
	13. Mechata Doupka Cave	Boev (in press - c)	Wurm	Popov (1984, 1985, in press)	1	0,63
	12. Filipovska Cave	Boev (in press - b)	Late Pleistocene	Popov, Pandurska (in press)	30	18,75
	11. Devetashkata Cave	Boev (1999 a)	Late Wurm (Middle Paleolithic)	St. Ivanova (unpubl data)	136	85,00
	10. Karlukovo 4 Cave	Mlikovski (1997)	Late Pleistocene	Mlikovski (1997)	2	1,25
	9. Temnata Doupka Cave	Boev (1994, 1999 - a)	Epigravettian - 31 900 - 13 600 B.P.	Popov (1990, 1994)	38	23,75
	8. Bacho Kiro Cave	Bochenski (1982)	Wurm		23	14,38
	7. Cave N 16	Boev (1999 a, b)	Riss-Wurm Interglacial - 50 000 - 18 000 B.P.	Popov (1990, 1994, 2000), Popov et al. (1994)	52	32,50
	6. Kozarnika Cave	Boev (in press - a)	80 000 - 16 000 B.P.	Popov (in press), Sirakov et al. (in press)	43	26,88
Middle	5. Morovitsa Cave	Boev (1999 a)	Steinheimian (Swanscombian) to Vertesszolos (Tarko) - 350 000 to 180 000 B.P.	Popov (1989, 1990)	8	5,00
Early	4. Temnata Doupka Cave	Boev (1999 a)	1,6 ma	Popov (1986, 1994)	8	5,00
	3. Cherdzenitsa Cave	Boev (2000 b)	Biharian – 1,6 ma	Popov (1990, 1994), Popov et al. (1994)	3	1,88
	2. Kunino	Boev (1999 a)	Vaalian – Menappian (Biharian) – 1,2-1,0 ma	N. Spassov (unpubl data)	7	4,38
	1. Balsha	Boev (2000 a)	MNQ 18-19	N. Spassov (unpubl data)	2	1,2
TOTAL					(160; all sites)	(160; all sites)

Tab.2 - Composition of the terrestrial vertebrate fauna of the Pleistocene avian sites of Bulgaria.

Site No	Type of deposit	References	Non-Avian fauna	Avian fauna (following Tyrberg, 1998)
1.	Fissure	N. Spassov (unpubl. data)	*Vulpes* sp.	*Lagopus* sp. (cf. *Lagopus*), cf. *Lagopus* sp.
2.	Fissure of a destroyed cave	N. Spassov (unpubl. data), V. Popov (unpubl. data)	*Canis mosbachensis ?Homotherium* sp./*Panthera spelea*, *Equus* sp./*?altidens*, *Cervus* sp., *Sus* sp., Felidae, Canidae, Bovidae, *Allophaiomys pliocaenicus Microtus hintoni*, *Hyppolagus brachignatus Pliomys* sp., *Prolagurus* cf. *pannonicus, Lepus* sp., Lagomorpha indet., Microtinae indet., Murinae indet.	*Falco* sp. ex gr. *cherrug*, cf. *Tetrao urogallus, Tetrao/Lagopus, Coturnix coturnix, Alectoris graeca, Pyrrhocorax pyrrhocorax, Coccothraustes coccothraustes*
3.	Cave	Popov (1990), Popov et. al. (1994)	*Sorex minitissimus, S. runtonensis, Beremendia fissidens, Ochotona* sp., *Spermophilus* sp., *Nannospalax* sp., *Apodemus sylvaticus/ flavicollis, Allocricetus bursae, Cricetus nanus, Pliomys simplicior, Clethrionomys glareolus, Lagurodon praepannonicus, L. arankae, Miomys pitymyoides, M. pusillus, Microtus pliocaenicus, M. burgondiae*	*Coturnix coturnix, Dendrocopus minor, Hirundo rustica, Hirundo daurica, Ptyonoprogne rupestris/Riparia riparia, Lanius collurio, Cinclus cinclus, Turdus merula, Turdus philomelos, Monticola* cf. *saxatilis, Sylvia* cf. *atricapilla, Pyrrhula pyrrhula, Carduelis cannabina, Passer* cf. *domesticus*
4.	Cave	Popov (1925 b), Popov (1990, 1994), Popov, Delchev (1997)	*U. spelaeus, C. spelaea, C. lupus, Bos primigenius, "Cervus tarandus", "Equus cabalus", "Elephas primigenius", Capra* sp. *Sicista subtilis, Microtus deucalion, Lagurodon arankae, L. praepannonicus, Spermophilus* sp., *Apodemus mysatacinus, Jordanomys major, S. minitus, Ochotona* sp., *Hypolagus brachignatus, Spermophilus promigenius,* Sp. cf. *nogaici, Sicista subtilis, Nannospalax* sp., *Apodemus mystacinus, Ap. Sylvaticus/ flavicollis, Allocricetus ehiki, Al. Bursae, Pliomys kretzoii, Borsodia hungarica, B. arankodes, Lagurodon praepannonicus, L. arankae, Jordanomys major, Miomys pitypyoides, M. pusillus, M. tornensis, M. deucalion*	*Aquila pomarina, Aquila chrysaetos, Aegypius monachus, Circus cyaneus, Buteo* sp. , *Falco tinnunculus, Falco* cf. *vespertinus, Falco* cf. *subbuteo, Falco* sp., *Coturnix coturnix, Perdix perdix, Alectoris graeca, ?Alectoris* sp., *Tetrao* sp., *Crex crex, Columba oenas, Streptopelia turtur, Bubo bubo, Strix aluco, Asio otus, ? Aegolius, Apus apus, Dendrocopus minor, Alauda arvensis, Lullula arborea, Riparia riparia, Lanius* cf. *Collurio, Turdus viscivorus, Turdus merula, Muscicapidae gen., Oenanthe oenanthe, Luscinia* cf. *Megarhynchos, Sturnus vulgaris, Pyrrhula pyrrhula, Nuciphraga caryocatactes, Pica pica, Corvus monedula, Corvus* sp., *Corvidae gen., Pyrrhocorax graculus, Passeres fam., Emberiza* sp.
5.	Cave	Nikolov (1983), Popov (1989, 1990)	*Crocuta spelaea, Talpa europaea, Sorex minutus, S. minitissimus, S. subaraneus, S. araneus, Crocidura zorzii, Ochotona* cf. *pusilla, Lepus capensis, Spermophilus citellus, Muscardinus avellanarius, Dryomyus nitedula, Glis glis, Sicista subtilis, Nannospalax leucodon, Apodemus sylvaticus/flavicollis, Allocricetus bursae, Cricetulus migratorius, Mesocricetus newtoni, Cricetus cricetus, Pliomys coronensis, Clethrionomys glareolus, Lagurus transiens, L. lagurus, Eulagurus luteus, Arvicola kalmakensis, Microtus subterraneus, Microtus arvalis/ agrestis, M. arvalidens, M. nivalis, M. chozaricus, Chionomys nivalis, Pliomys lenki*	*Perdix perdix, Alectoris graeca, Coturnix coturnix, Alauda arvensis, Pyrrhocorax graculus*
6.	Cave	Nikolov (1983), M. Marinska (unpubl. data)	*Ursus arctos, U. spelaeus, Bos* sp., *Homo sapiens*, Ovicaprinae indet., *Talpa europaea, Sorex araneus, S. minutus, Crocidura suaveolens, Neomys* sp., *Lepus* sp.,	*Anas crecca, Falco tinnunculus, Falco vespertinus, Falco* sp. ex gr. *tinnunculus, Tetrao urogallus, Tetrao tetrix/urogallus Tetrao tetrix, Lagopus lagopus, Lagopus lagopus/Tetrao tetrix, Lagopus lagopus/mutus, Lagopus/Tetrao, Tetrastes bonasia,*

		pers. unpubl. data, Sirakov et al. (in press)	*Ochotona pusilla, Allactaga jaculus, Mesocricetus newtoni, Cricetulus migratorius, Spermophilus citelus, Nannospalax leucodon, Lagurus lagurus, Clethrionomys glareolus, Microtus arvalis, Microtus ?agrestis, Pytimys subterraneus, Chionomys nivalis, Microtus oeconomus, Arvicola terrestris, Sicista subtilis, Apodemus microps, A.* sp. ex. gr. *sylvaticus,* Pisces, Lacertidae, Chiroptera	*Perdix palaeoperdix, Perdix perdix/palaeoperdix, Perdix perdix, Perdix* sp., *Perdix/Alectoris, Alectoris graeca/chukar,* cf. *Alectoris, Coturnix coturnix, Coturnix/Perdix, Porzana* cf. *parva, Crex crex, Gallinula chloropus, Tringa stagnatilis, T. totanus, Tringa* sp., cf. *Charadrius,, Apus apus, Nyctea scandiaca, ?Aegolius funereus, Athene noctua, Eremophila alpestris, Anthus trivialis, Hirundo daurica, Ptionoprogne rupestris, Riparia riparia, Lanius collurio,* cf. *Erithacus* sp., *Monticola saxatilis, Turdus merula, T. viscivorus, Carduelis carduelis, C. cannabina, Fringilla coelebs, Coccothraustes coccothraustes, Loxia curvirostra,* cf. *Pyrrhula pyrrhula, Garrulus glandarius, Pyrrhocorax graculus, P. graculus/Corvus monedula, Pyrrhocorax* cf. *Pyrrhocorax, Corvus monedula, C. corone, C. corone/frugilegus, Corvus* sp.
7.	Cave	Popov (1990, 1994; 2000 …), Popov et al. (1994)	*Talpa europaea, Sorex araneus, S. minutus, S. minitissimus, Crocidura leucodon, Neomys fodiens, Rinolophus ferumequinum, Myothis blythi, M. bechsteini, M. natterei, M.* cf. *mystacinus, M.* ex gr. *daubentoni, Plecotus* cf. *auritus, Barbastela* cf. *darjelingensis, Miniopterus schreibersi, Eptesicus serotinus, E. nilssoni, Vespertilio murinus, Pipistrellus pipistrellus, Nyctalus noctula, N. leisleri, N. lasiopterus, Lepus* cf. *capensis, Ochotona pusilla, Spermophilus* sp., *Muscardinus avellanarius, Dryomys nitedula, Glis glis, Sicista subtilis, Alactaga major, Nannospalax leucodon, Sylvaemus flavicollis, S. uralensis, Mus* cf. *spicilegus, Cricetulus migratorius, Mesocricetus newtoni, Cricetus cricetus, Clethrionomys glareolus, Lagurus lagurus, Eulagurus luteus, Arvicola terrestris, Microtus* (s. str.) ex gr. *arvalis-agrestris, Microtus (Stenocranius)* cf. *agrestris, Microtus (Terricola) subterraneus, Chionomys nivalis*	*Accipiter nisus, Accipiter* sp.. *Falco tinnunculus, F.* sp. *ex gr. tinnunculus, F. vespertinus, Falco* sp., *Coturnix coturnix, Perdix perdix, P.* cf *paleoperdix,* cf *Pedrix* sp., *Perdix/Alectoris,* cf. *Alectoris* sp., *Phasianus colchicus, Tetrao tetrix, Lagopus lagopus/mutus,* cf. *Tetrastes bonasia, Porzana parva/pussila, Crex crex, Rallus aquaticus, Gallinula chloropus, Larus* cf *ridibundus, Otus scops, Strix aluco, Asio otus/flammeus, Columba livia, Culumba livia/oenas, Columba* sp., *Apus apus, Apus melba, Dendrocopus minor, Alauda arvensis, Anthus trivialis, Delichon urbica, Ptyonoprogne rupestris/Riparia riparia, Turdus merula, T. philomelos, T. torquatus, T. pilaris, Turdus* sp., *Monticola* cf *saxatilis, Erithacus rubecula, Bombycilla garrulus, Cettia cetti, Lanius* cf *collurio, Sitta* cf *europaea, Carduelis cannabina, Fringilla coelebs, Fringilla* sp., *Loxia curvirostra, Pyrrhula pyrrhula, Passer montanus, Passer* sp., *Sturnus vulgaris, Garrulus glandarius, Pica pica, Corvus frugilegus, C. monedula, C. corax, Corvus* sp., *Pyrrhocorax graculus,* cf *Nucifraga caryocatactes*
8.	Cave	Bochenski (1982)		*Anas platyrhynchos, Aquila chrysaetos, Circus aeruginosus, Lagopus mutus, Perdix perdix, Coturnix coturnix, Alectoris graeca, Gallus gallus, Rallus aquaticus, Porzana porzana, Gallinula chloropus,* cf. *Bubo bubo,* cf. *Ptyonoprogne rupestris, Delichon urbica,* cf. *Lullula arborea, Alauda arvensis,* cf. *Anthus campestris, Pyrrhocorax pyrrhocorax, P. graculus, Corvus monedula, C. corax*, cf. *Turdus philomelos*, *Loxia curvirostra*
9.	Cave	Popov (in press)		*Coturnix coturnix*, cf. *Riparia riparia,Corvus monedula, Lillula arborea, Turdis viscivorus, Buteo* sp., *Luscinia* cf. *megarhynchos*
10.	Cave	Mlikovsky (1997); Horacek (1982)	Anura (1 sp.), Lacertilia (1 sp.), Mammalia (28 spp., incl. 13 spp. Of Chiroptera) (Horacek (1982)	*Turdus* sp., *Pyrrhocorax graculus*
11.	Cave	N. Spassov (unpubl. data)	*Mustela nivalis, ?M. erminea, Lepus capensis, Talpa europaea, Allactaga ?major*	*Podiceps cristatus, P. griseigena, Anser* cf. *erythropus, Branta ruficollis, Anas platyrhynchos, A. crecca, A. crecca/querquedula, A. penelope, A. acuta, A. querquedula, A. strepera, A. clypeata, Anas* sp., *Netta ruffina, Aythya fuligula, A. nyroca, A. ferina, Aythya* sp., *Bucephala clangula, B. clangula/Melanita* sp. *Melanita nigra, Aquila pomarina, Circus aeruginosus, Buteo lagopus, B. buteo, Accipiter nisus, A. gentilis, Accipiter* sp., *Falco tinnunculus, F.* sp. Ex gr. *tinnunculus, F.* cf. *subbuteo, F. vespertinus, Tetrao tetrix, T. tetrix/urogallus, T. urogallus, Tetrao/Lagopus, Lagopus lagopus, L. mutus/lagopus, Tetrastes bonasia, Coturnix coturnix, Perdix palaeoperdix, P. perdix/palaeoperdix, P. perdix,* cf. *Pedix* sp., *Phasianus colchicus, Alectoris*

				graeca/chukar, Gallinula chloropus, Crex crex, Rallus aquaticus, Porzana pusilla, Tetrax tetrax, Otis/Tetrax, Vanellus vanellus, Recurvirostra avosetta, Himantopus himantopus, Philomachos pugnax, Pluvialis squatarola, Numenius phaeopus/teniurostris, Actitis hypoleucos, Tringa glareola, T. totanus, T. ochropus, T. stagnatilis, T. nebularia, Tringa sp., *Calidris alba, Limosa limosa, Gallinago media, G. gallinago, Scolopax rusticola, Sterna hirundo, Sterna* sp., *Larus* cf. *canus, Larus* cf. *ridibundus, Larus* sp., *Larus/Sterna, Chlidonias* sp., *Gelochelidon* cf. *nilotica,* cf. *Nyctea scandiaca, Athene noctua, Aegolius/Athene, Aegolius fnereus, ?Aegolius funereus, Asio otus/flammeus, Asio otus, A. flammeus, ?Surnia ulula, Strix aluco, Strix* aff. *nebulosa, Glaucidium passerinum, Columba livia, Cuculus canorus, Apus apus, Dendrocopus major, Dendrocopus* cf. *minor, Alauda arvensis, Lullula arborea, Eremophila alpestris, Ptyonoprogne rupestris/Riparia riparia, Hirundo daurica, Anthus trivialis, Sylvia communis, Ficedula* cf. *albicollis, Turdus merula, Turdus viscivorus, Turdus iliacus, Turdus philomelos,* cf. *Turdus* sp., *Pyrrhula pyrrhula, Coccothraustes coccothraustes, Sturnus vulgaris, Garrulus glandarius, Corvus monedula, C. monedula/Pyrrhocorax graculus, C. corone, C. frugilegus, C. corone/frugilegus, C. corax,* cf. *Corvus* sp., *Nucifraga caryocatactes, Pica pica, Pyrrhocorax graculus, P. pyrrhocorax, Pyrrhocorax* sp.
12.	Cave	(Popov, Pandurska, in press).	*Crocidura leucodon, Myotis bechsteinii, Myotis nattereri, Vespertilio murinus, Meles meles, Spelaearctos spelaeus, Mesocricetus newtoni, Chionomys nivalis, Sorex araneus, Sylvaemus* ex gr. *Sylvaticus-flavicollis, Microtus arvalis, Lagurus lagurus, Microtus subterraneus, Arvicola terrestris, Talpa europaea, Sorex minutus, Neomys, Rhinolophus hipposideros, Rhinolophus mehelyi, Ochotona pusilla, Myoxus glis, Nannospalax leucodon, Sylvaemus* sp., *S. uralensis, Cricetulus migratorius, Clethrionomys glareolus*	*Falco* sp. ex. gr. *tinnunculus, Lagopus* cf. *lagopus, Tetrao tetrix, Coturnix coturnix, Perdix perdix/palaeoperdix, Phasianus colchicus, Athene noctua, Hirundo rustica, Sitta europaea, Prunella modularis, Erithacus rubecula, Carduelis* sp., *Pyrrhula pyrrhula, Sturnus vulgaris, Corvus monedula, Corvus* sp., *Pyrrhocorax graculus, Pyrrhocorax graculus/pyrrhocorax, Pyrrhocorax pyrrhocorax, Pica pica*
13.	Cave	………….		*Perdix perdix*
14.	Cave	Popov (1933), Popov (1983), Nikolov (1983), pers. unpubl. data		*Tetrao tetrix, Pica pica*
15.	Cave	N. Spassov (unpubl. data)	*U. spelaeus*	*Falco subbuteo, Coturnix coturnix, Corvus monedula, Pyrrhocorax graculus*
16.	Cave			*Perdix perdix, Lanius* cf. *collurio, Turdus merula, T. iliacus, Corvus monedula*
17.	Cave			*Monticola* cf. *saxatilis, Corvus monedula*
18.	Cave	Popov (in presss - …),	*Crocidura leucodon, Chionomys nivalis, Terricola* sp., *Cuon alpinus, Capra ibex*	*Anser* sp., *Anas* sp., *Tetrao tetrix, Tetrastes bonasia, Perdix palaeoperdix, P. perdix, Perdix* sp., *Coturnix coturnix, Crex crex, Tringa* cf. *stagnatilis, Athene noctua, Asio otus, Apus melba, Melanocorypha* sp., *Anthus* cf. *trivialis, Anthus* sp., *Parus major, Sylvia* sp., *Ptyonoprogne rupestris, Fringilla montifringilla, Loxia curvirostra, Coccothraustes coccothraustes, Carduelis chloris,* cf. *Garrulus glandarius, Corvus monedula, C. corone/frugilegus, C. monedula/Pyrrhocorax graculus, Corvus* sp., *Pyrrhocorax graculus, P. pyrrhocorax,* cf. *Pyrrhocorax* sp., *Petronia petronia*

Besides *L. mutus*, 5 other disappeared species have been established: *Lagopus lagopus, Tetrao tetrix, Phasianus colchicus* (native subspecies *colchicus* form), *Nyctea scandiaca* and *Pyrrhocorax pyrrhocorax*. One species (*Perdix palaeoperdix*) is fossil. Four Late Pleistocene sites probably prove the coexistence with the modern *Perdix perdix.* They are the youngest record so far of that extinct species. The present study summarizes all data on the Pleistocene bird faunas of Bulgaria, based on 5770 avian bone fossils from 18 localities. One site, the Temnata Doupka Cave contains fossils boths of the Early and the Late Pleistocene (Tabs 1, 2). The complete taxonomic list includes 160 recognized species at least (Tab. 2).

REFERENCES

Bochenski, Z. 1982. Aves. In J. Kozlowski (ed.), *Excavations in the Bacho Kiro Cave (Bulgaria). Final report*: 31-38. Warszawa: Panstwowe Wydawnictwo Naukowe.

Boev, Z.N. 1994. The Upper Pleistocene Birds. In J. Kozlowski, J. K., H. Laville & B. Ginter (eds.), *Temnata Cave. Excavations in Karlukovo Karst Area, Bulgaria,* 1.2., 55-86. Cracow: Jagellonian Univ. Press.

Boev, Z.N. 1999a. *Neogene and Quaternary birds (Aves) from Bulgaria.* Sofia*:* National Museum of Natural History, Bulgarian Academy of Sciences.

Boev, Z.N. 1999b. The Middle Pleistocene avifauna of the Cave No 16 (NW Bulgaria) and its palaeoecological implication. *8th International Congress on the Zoogeography and Ecology of Greece and Adjacent Regions, Kavala, 17-21 May 1999. 8th ICZEGAR Abstracts*: 21-22. Hellenic Zoological Society.

Boev, Z.N. 2000a. Neogene avifaunas of Bulgaria. *Vertebrata PalAsiatica*, Beijing. 38 - Supplement, 2-3.

Boev, Z.N. 2000b. Early Pleistocene and Early Holocene Avifauna of the Cherdzhenitsa Cave, Northwestern Bulgaria. *Historia naturalis bulgarica*, 11: 107-116.

Boev, Z.N. 2000c. Late Pleistocene Avifauna of the Razhishkata Cave (W Bulgaria). *Historia naturalis bulgarica*, 12: 71-87.

Boev, Z.N. (in press, a). Late Pleistocene birds from the Kozarnika Cave (Montana District; NW Bulgaria). In *Environment and Cultural Heritage in the Karst Areas. National Conference, 10-12 November 2000, Sofia.*

Boev, Z.N. (in press, b). Late Pleistocene and Holocene avifauna from three caves in the vicinity of Tran (Pernik District - W Bulgaria). In *Environment and Cultural Heritage in the Karst Areas. National Conference, 10-12 November 2000, Sofia.*

Boev, Z.N. (in press, c). Late Pleistocene and Holocene avian finds from the vicinity of the Lakatnik r/w Station (W Bulgaria). In *Environment and Cultural Heritage in the Karst Areas. National Conference, 10-12 November 2000, Sofia.*

Mlikovsky, J. 1997. Late Pleistocene birds of Karlukovo, Bulgaria. *Historia naturalis bulgarica* 7: 59-60.

Nikolov, I. 1983. Some notes on the cave fossil mammalian fauna in Bulgaria. In *4th European Regional Conference of Speleology. October, 1981, Sofia*: 215-218. (In Bulgarian, Engl. Summ.).

Peschev, T.H., Peschev, D.T. and Popov, V.V. (in press). *The Fauna of Bulgaria. Mammalia*. Sofia: Prof. Marin Drinov Acad. Publ. House.

Popov, V.V. 1983. Paleontological explorations in the caves (significance, methods, achieved results and trends of developments). In *4th National Conf. "The links between the Science and the Practice in the Speleology". Varna, 31.03.-3.04.1983*: 36-48. (In Bulgarian, Engl. Summ.).

Popov, V.V. 1984. Small mammals (Mammalia: Insectivora, Lagomorpha, Rodentia) of the Upper Pleistocene deposits in the Mechata Doupka Cave (Western Stara Planina Mts.) I. Taphonomy, paleoecological and zoogeographycal peculiarities. *Acta zoologica bulgarica* 24: 35-44.

Popov, V.V. 1985. Small mammals (Mammalia: Insectivora, Lagomorpha, Rodentia) of the Upper Pleistocene deposits in the Mechata

Doupka Cave (Western Stara Planina Mts.) I. Description of species. *Acta zoologica bulgarica*, 26: 23-49.

Popov, V.V. 1986. Early Pleistocene Rodentia (Mammalia) from the “Temnata dupka” cave near Karlukovo (North Bulgaria). *Acta zoologica bulgarica*, 30: 3-14.

Popov, V.V. 1989. Middle Pleistocene small mammals (Mammalia: Insectivora, Lagomorpha, Rodentia) from Morovitsa Cave (North Bulgaria). *Acta zoologica carcoviensia*, 32, 13: 561-588.

Popov, V.V. 1990. *Quaternary small mammals (Mammalia: Insectivora, Lagomorpha, Rodentia) of the Western Pre-Balkan. Morphology, paleowcology, biostratigraphy*. Synopsis of the Ph. D. dissert. Institute of zoology, Bulg. Acad. of Sci. Sofia, 1-30.

Popov, V.V. 1994. Quaternary small mammals from deposits in Temnata - Prohodna Cave system. In J. Kozlowski, J. K., H. Laville & B. Ginter (eds.), *Temnata Cave. Excavations in Karlukovo Karst Area, Bulgaria, 1.2.*: 11-53. Cracow: Jagellonian Univ. Press.

Popov, V.V. 2000. The small mammals (Mammalia: Insectivora, Chiroptera, Lagomorpha, Rodentia) from Cave 16 (North Bulgaria) and the paleoenvironmental changes during the Late Pleistocene. In B. Ginter, J. K. Kozlowski, J.-L. Guadelli, K. Laville (eds.), *Temnata Cave. Excavations in Karlukovo Karst Area, Bulgaria, vol.2, part 1*: 159-240. Cracow: Jagellonian Univ. Press.

Popov, V.V. (in press). *Mammalian fauna of Bulgaria*. In Peschev, T., Peschev, D. and Popov, V.V. (in press). The Fauna of Bulgaria. vol. 2X. Mammalia. Sofia: Prof. Marin Drinov Acad. Publ. House.

Popov, V.V., Gerasimov, S., Marinska, M. 1994. Multivariate palaeoecological analysis of a Late Quaternary small mammal succession from North Bulgaria. *Historical biology*, 8: 261-274.

Popov, V.V., Pandurska, R. (in press). Late Quaternary mammals (Mammalia: Insectivora, Rodentia, Lagomorpha) from the sediments of Filipovska Cave (Western Bulgaria). In *Environment and Cultural Heritage in the Karst Areas*. National Conference, 10-12 November 2000, Sofia.

Sirakov. N., Laville, H., Ivanova, St., Popov, V., (In press). Kozarnika Cave (Bulgaria): New perspectives for the Balkanian Paleolithic studies. *Geoarchaeology*, 9.

Tyrberg, T. 1998. *Pleistocene birds of the Palearctic: a catalogue*: 1-720. Publ. of the Nuttall Ornithol. Club, No 27, Cambridge, Massatchusetts.

The Mercure River Basin (Southern Italy): Quaternary stratigraphy and large mammal biochronology

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SUMMARY: A preliminary analysis of the Quaternary geological evolution of the Mercure River Basin is presentend, together with the biochronological framework of the mammal faunas found in this area. The Mercure Basin is located along a regional tectonic discontinuity (Mt. Pollino area), that was filled during Quaternary times with fluvial and lacustrine deposits. Three main sedimentary phases have been identified. An almost complete skeleton of *Elephas antiquus* has been found within fluvial deposits of the lower cycle, in the Calorie locality. During the last twenty years several large mammal bones coming from different localities of this area have been collected. The analysis of the mammal remains allowed the recognition of at least two distinct faunal assemblages: the older (including *Elephas antiquus*) is referable to the Middle Pleistocene (Galerian mammal age), the younger to the Late Pleistocene (late Aurelian).

1. INTRODUCTION

The Mercure Basin is one of the southern Apennine intramountain basins, located along a regional tectonic discontinuity (Mt. Pollino area), that was filled during Quaternary times with fluvial and lacustrine deposits (Monaco *et al.* 1995). The origin of this basin is related to the extensional and transtensional tectonic events which occurred in this part of the Apennine chain, starting from Early and/or Middle Pleistocene (Schiattarella *et al.* 1994). The Pleistocene successions, from the bottom to the top, include alternating conglomerates and sands, which pass to carbonate silty deposits that end with gravel deposits. The finding of mammal fossil bones in the gravels of the lower cycle and the biochronological analysis of the fossils coming from other localities of the area, gave reliable chronological constraints to the study of the Quaternary evolution of the basin.

2. GEOLOGICAL SETTING

The reconstruction of the Quaternary sedimentary succession of the basin allows the definition of three main phases of the Mercure Basin filling (Fig. 1) which occurred during the entire Pleistocene time span.

a) In the first sedimentary phase (from Early? to Middle Pleistocene), thick gravel and sandy deposits, in alluvial fan and fluvial facies, took place (250-300 m of thickness; Fig. 1). These deposits outcrop in the southern part of the basin and have been also found in boreholes in the northern area. Abundant mammal remains were found at the top of these deposits.

b) The second phase of filling (Middle Pleistocene) is characterised, from the bottom to the top, by: alternating clay-silty deposits (70-80 m), discontinuous lignite levels of marshy origin (north-central area), passing to carbonate silts of open to marginal lacustrine environment (south-central area, 130 m of thickness). The fossil assemblages are characterised by rich mollusc and ostracod assemblages without any mammal fauna.

c) Finally, in the Late Pleistocene the tectonic and climatic events produced the incision of the lake threshold, the renewal of pattern drainages and the deposition of fluvial coarse-grained deposits.

The basin is bounded by several tectonic elements with SW-NE and WNW-ESE direction, with a normal and/or transtensive component which control its sedimentary evolution.

The Mercure fault system which displaced toward North the Quaternary successions (Fig. 1) can be considered as one of the most important in the area. The activity of the Mercure fault produces the uplift the southern part of the basin (the Rotonda area) in relation to the northern sector, giving the start to erosional phenomena on the Middle Pleistocene lacustrine deposits. As a consequence of these features, the lacustrine deposits outcropping in the southern area show minor thickness (70-80 m) than those from the deposits of the northern part (100-130 m).

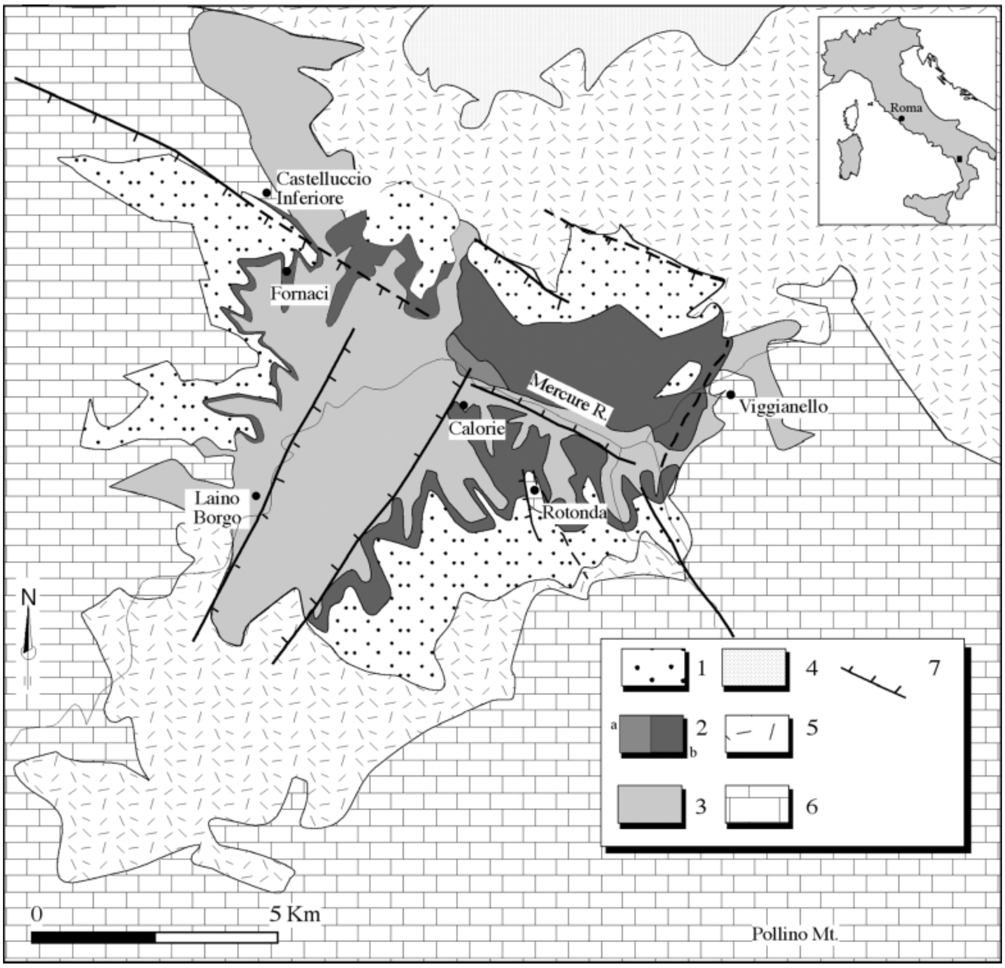

Fig.1 - Geological map of the Mercure Basin. Legend: 1 – Alluvial fan (Upper Pleistocene); 2) Palustrine (a) and lacustrine deposits (b) (Middle Pleistocene) (with molluscs and ostracods); 3) Alluvial fan and fluvial deposits with mammal fauna (? Lower Pleistocene-Middle Pleistocene); 4) S. Arcangelo flysch (Upper Pliocene); 5) Frido Unit (Cretaceous); 6) Maddalena and Pollino Unit (Triassic-Miocene); 7) Normal and transtensional faults.

Fig.2 - Mandible of *Stephanorhinus hundsheimensis* from Calorie.

3. BIOSTRATIGRAPHY AND BIOCHRONOLOGY

Fossil bones of large mammals generically referable to Middle Pleistocene, coming from the fluvial deposits of the first filling phase in the southern area of the Mercure Basin, have been found. In particular, in locality Calorie in the Eighties, an almost complete skeleton of *Elephas antiquus* Falconer & Cautley has been discovered. The bones, recently restored, are still to be studied in detail. The general taphonomical features on the excavation area showed evidences of a short transportation by the fluvial stream and a quick burial of the carcass of the elephant. Today the fossil bones of the straight-tusked elephant and several other Pleistocene mammal remains are stored at the Museo Naturalistico of Rotonda.

New material, a mandible of a rhino (Fig. 2) and some teeth of hippos, were collected during a recent excavation carried on by some of the authors of the present paper (June 1997) at Calorie site. The fossils are stored today at the Soprintendenza Archeologica of Policoro and are still under study.

A preliminary analysis of the fossil bones coming from the same level from which the skeleton of *Elephas antiquus* was excavated, allowed the classification of *Stephanorhinus hundsheimensis* Toula and of *Hippopotamus antiquus* Desmarest. This assemblage is referable to the Galerian mammal age (early Middle Pleistocene; Gliozzi *et al.* 1997).

The fossil bones stored in the Museum of Rotonda come from different localities of this area and stratigraphical levels. Remains of large mammals come from Fornaci (Fondo Pagano, Castelluccio inferiore), but should pertain to different faunal assemblages. In fact, a metacarpal of a large megacerine, probably pertaining to *Megaceroides* ex gr. *M. verticornis*, some molar teeth referred to *Dama* cf. *D. clactoniana*, and the distal part of a metatarsal of *Bison* sp. (fitting in the biometrical range of *Bison schoetensacki*, but an attribution to *Bison priscus* is also possible) testify the occurrence of Galerian taxa. From the same locality also taxa with modern features have been recorded: *Dama dama* (Frisch), *Cervus elaphus* Linnaeus (advanced form) and *Equus hydruntinus* Regalia. Remains of these three taxa come also from the Scaldacane locality (near Rotonda, Fig. 1). The analysis of the fossil material suggests at least the occurrence of two different faunal assemblages:

1) *Elephas antiquus*, *Stephanorhinus hundsheimensis*, *Hippopotamus antiquus* from Calorie (with stratigraphical control) and taxa coming from a correlated level: *Megaceroides* ex gr. *M. verticornis, Dama* cf. *D. clactoniana* and *Bison* sp. (Fornaci-Fondo Pagano); all these could be referred to Middle Galerian

F.U., probably Ponte Galeria or Isernia F.U. (Petronio & Sardella 1999);

2) *Dama dama*, *Cervus elaphus*, and *Equus hydruntinus* referable to the late Aurelian (Late Pleistocene) (Di Stefano & Petronio, 1997; Gliozzi *et al.* 1997).

4. CONCLUSIONS

The occurrence of at least two distinct faunal assemblages gave biostratigraphical constrains to the evolution of the sedimentary successions occurring in the Mercure basin. On the basis of the mammal assemblage which have been found at the top of the sequences, the alluvial deposits of the first filling phase have been attributed to Middle Pleistocene. This mammal fauna, where an *E. antiquus* skeleton in anatomical connection was found, testified the quick burial of the carcasses during the sedimentation of the alluvial plain sequences. The second lacustrine phase filling deposits, devoid of mammal fauna but rich of mollusc and ostracod assemblages, are related to the uppermost part of Middle Pleistocene. The Late Pleistocene mammal fauna assemblages, associated in the southern part of the basin with the Middle Pleistocene fauna, suggest the transport and deposition of teeth and skeleton fragments onto the lower alluvial deposits. This is probably related to the quick erosion of the Middle Pleistocene lacustrine deposits during the last climatic and tectonic events which occurred in the Mercure Basin.

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6. REFERENCES

Di Stefano, G. & Petronio, C. 1997. Origin and evolution of the European fallow deer (*Dama*, Pleistocene). *N. Jb. Geol. Palaeont. Abh*. 203: 57-75.

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 in Italy. The state of the art. *Riv. Ital. Paleont. Strat.* 103: 369-388.

Monaco, C., Tortorici, L., Mortau, L., Critelli, S. & Tansi, C. 1995. Geologia del versante Nord-Orientale del massiccio del Pollino (confine Calabro-Lucano): nota illustrativa sintetica della carta Geologica alla scala 1:50.000. *Boll. Soc. Geol. It*. 114: 277-291.

Petronio, C. & Sardella, R. 1999. Biochronology of the Pleistocene mammal fauna from Ponte Galeria (Rome) and remarks on the Middle Galerian faunas. *Riv. Ital. Paleont. Strat.* 105(1): 155-164.

Schiattarella, M., Torrente, M.M. & Russo, B. 1994. Analisi strutturali ed osservazione morfo-stratigrafiche nel Bacino del Mercure. *Il Quaternario* 7: 613- 626.

The *Elephas recki* site of Haïdalo (Republic of Djibouti)

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SUMMARY: The Djibouti palaeontological and archaeological mission supervised by J. Chavaillon, excavated between 1985 and 1992 several Lower and Middle Palaeolithic sites. At Haidalo the complete skeleton, still in its anatomical position, of a Lower Pleistocene elephant was excavated. From a stratigraphical and sedimentological point of view the find lies in the later deposits of the Lower to Middle Pleistocene of the Gobaad Formation. The fossilised elephant bone remains lay in the reddish brown clays apparently at the base of the deposit subsequently covered by the hardened clays and sand. From a palaeontological perspective it is the first time in this area that a complete skeleton of *Elephas recki recki* has been found in a good state of preservation and what is more in anatomical connection.

The purpose of the archaeological and palaeontological missions between 1985 and 1992 was to detect, survey and occasionally excavate Lower and Middle Palaeolithic sites in the As Eyla region. These tend to lie in the west of the country for an essential reason: it is there that the waters of the now dry riverbed of the Awash used to flow out into the swampy Gobaad lakes. The faunal evidence that remains was not buried beneath the ensuing volcanic activity during the Pleistocene or Holocene making the Gobaad a privileged site.

The number of sites from which mammal remains have been retrieved is limited. However, bearing this in mind, there is a high proportion of sites in Djibouti with a distribution of elephant bones. This contrasts with relatively fewer sites in other countries. Amongst others, distributions from Annabokoma to the west of Dikhil, and Barogali and Haïdalo to the north and west of As Eyla, respectively can be cited.

A young shepherd pointed out the Haïdalo site to us. This is not a surface bone scatter site. All that could be seen emerging from the Pleistocene flood deposits was the end of the tibia of a big mammal. It was decided to excavate using the method previously adopted at the Barogali butchery site a few kilometres to the north. Thus the complete skeleton, still in its anatomical position, of a Lower Pleistocene elephant was excavated.

What was most interesting about the find was that rather than an unarticulated scatter of surface bone fragments, this was a complete animal lying below 1,2 m of sediment.

From a stratigraphical and sedimentological point of view the find lies in the later deposits of the Lower to Middle Pleistocene of the Gobaad Formation. The layers that were distinguishable were visible in a natural section covered by a greenish clay deposit. The stratigraphic sequence immediately above the bone scatter was as follows: at the base compacted brownish red clays; beige clayey sand; a bank of sand, very compacted and hardened due to chalky infiltration. The sequence was sealed by 1,2 m of light brown chalky clays. The section beneath the fossil is a chalky crust of crumbling ridge. A few hundred metres away, it is possible to see later swampy river deposits in the stratigraphic sequence.

The fossilised elephant bone remains were found in the reddish brown clays apparently at the base of the deposit subsequently covered by the hardened clays and sand. The pelvic bones and the upper cranium were isolated within the chalky light beige clays.

This would indicate a situation associated with fluvial deposits. A fairly intense period of activity - the sand deposit – sandwiched between two calm events – the reddish clays below, beige clays with chalky infiltration above. During the period of river activity the body of the elephant might have been dragged by the current and then rapidly buried beneath the more clayey sandy deposits.

It is remarkable that the skeleton of a big elephant could have reached the present day in near-anatomical position.

By the end of the excavation the 16 square metres of the site had revealed what remained of a big elephant, probably lying on its side.

The pelvis is still anatomically connected to the spinal column. A dozen ribs are still attached to the 24 vertebrae though some are fairly shattered. The skull, the atlas and the epistropheus do not lie in line with the pelvis/spinal column, but have rotated some 180°. Though the limbs of the animal have become detached from the body, three of them still have their bones in anatomical position.

A study of the teeth has enabled Cl. Guérin and M. Faure to accurately determine the subspecies of the animal. Following M. Beden (1979, 1985), the height, width, spacing and shape of the teeth are typical of *Elephas recki recki*, known in Africa between 1.2 and 0.5 Ma. The Haïdalo animal is similar to other specimens found in Olduvai Bed IV (Tanzania), at Koobi Fora, locality 103 and Olorgesailie (Kenya), and in the Upper Member L of the Shungura Formation at Omo Valley (Ethiopia).

Elephas r. recki had already been found in the Republic of Djibouti. A group of geologists had come across evidence as to its existence in 1974 to the southwest of Lake Assal and also in Gobaad. Further evidence was found in the same region by a group of geologists that included H. Thomas. A subsequent team led by L. de Bonis (de Bonis *et al.* 1988) found fragments of molars, amongst which some were ascribed to *Elephas r. recki.*

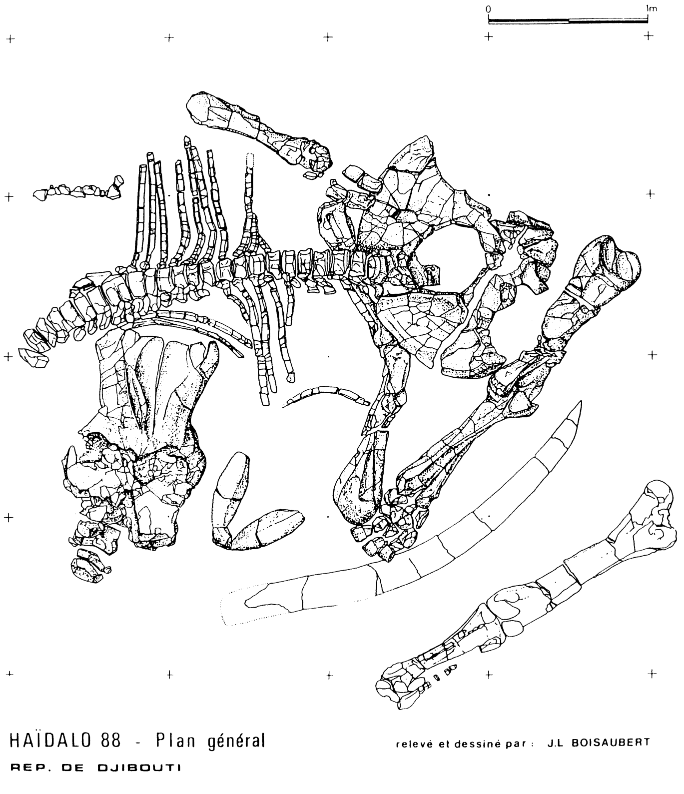

Fig. 1 - General plan of the Haïdalo excavation (Drawing by J.L. Boisaubert).


Fig. 2 - Haïdalo: the skeleton of *Elephas recki recki*.

The stratigraphic sequences pertinent to the fossilised elephants of Haïdalo (*E. recki recki*) and Barogali (*E. r. ileretensis*) are compatible: the Haïdalo elephant lies in deposits younger than the Barogali ones (Berthelet 2001).

Interest in the Haïdalo site is twofold (Chavaillon *et al.* 1990):

- from a palaeontological perspective it is the first time a complete skeleton of *Elephas r. recki* has been found in a good state of preservation and what's more in its anatomical position.
- from an ecological and taphonomical perspective, given that it does not appear to have fallen prey to other animals due to its immediate burial, the Haïdalo elephant will be an essential source for comparison not only with present day elephants but also with elephant remains from bone scatters on Palaeolithic butchery sites.

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REFERENCES

Beden, M. 1979. *Les Eléphants d'Afrique Orientale: systematique, phylogénie, interêt biochronologique.* Thèse de Doctorat d'Etat, Université de Poitiers. 2 vol.

Beden, M. 1985. *L'environnement des Hominidés au Plio-Pleistocène*: 21-44. Fondation Singer-Polignac, Juin 1981, Paris: Masson.

Berthelet, A. 2001. L'outillage lithique du site de dépeçage à *Elephas recki ileretensis* de Barogali (République de Djibouti), *C. R. Acad. Sci. Paris.* II, 332: 411-416.

Bonis, L. de, Geraads, D., Jaegger, J.J., Sen, S. 1988. Vertébrés du Pléistocène de Djibouti, *Bull. Soc. Géol.Fr.,* (8), IV, (2): 323-334.

Chavaillon, J., Berthelet, A., Boisaubert, J.L., Faure, M., Guérin, Cl., Warsama, S.A. 1990. Un *Elephas recki* découvert en connexion anatomique dans le site de Haïdalo, près de As Eyla (république de Djibouti), *C. R. Acad. Sci. Paris.* II, 310 : 441-446.

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The Paleolithic finds from Bollschweil and the question of Neanderthal mammoth hunting in the Black Forest

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SUMMARY: From 1996 to 1998 excavations in Bollschweil, near Freiburg in Breisgau, yielded several hundred faunal remains and a small lithic assemblage. The finds were preserved in a small loess and rubble-filled valley on the edge of a limestone quarry. Biostratigraphic and cultural stratigraphic arguments, as well as ESR dates suggest that the accumulation dates to the penultimate glaciation, but the reworked nature of the sediments in the gully complicate the archaeological and chronological interpretation of the site. The lithic assemblage includes an amphibolite handaxe and a chert side scraper. The fauna is dominated by mammoth with fewer remains of horse, large bovid, woolly rhinoceros, red deer and bear. At least six mammoths are included in this assemblage, which is characterized by a wide range of body parts. The finds lack clear anthropogenic modifications. As is often the case at proboscidean sites, a definitive causal association between the faunal remains and hominid economic behavior is difficult to establish.

1. INTRODUCTION

After the site's discovery in 1995, amateur paleontologists E. Blattmann and R. Ritz began excavating the rich Pleistocene faunal remains exposed in a small, steep valley on the edge of the limestone quarry operated by the Koch company in Bollschweil, 10 km SE of Freiburg in the Black Forest of southwestern Germany. In 1997 the site, which had already produced scores of faunal remains and a small number of lithic artifacts, was called to the attention of the State Agency for Archaeological Heritage (*Landesamt für Denkmalpflege*) and the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen. In the fall of 1997 a team of archaeologists from Tübingen conducted a salvage excavation focusing on clarifying the geological setting of the finds and augmenting the existing collections of faunal remains and lithic artifacts. This excavation (Figs. 1-3) ran for 10 weeks and yielded a wealth of new information about the site (Conard & Kandel 1999). Subsequent research has addressed the lithic assemblage from the site (Conard & Blattmann 2000) and the chronostratigraphic assessment of the site (Rink *et al.* n.d.).

2. GEOLOGICAL SETTING

The Paleolithic site of Bollschweil is located near the northwestern edge of the Koch limestone quarry at an elevation of 370 m above sea level. The finds lay near the base of a small north-south oriented valley formed on its eastern border by Jurassic limestone bedrock and to the west by limestone blocks and sediments. While this small gully-like valley probably was fed occasionally by runoff, there is no indication that it was ever a perennial water course. The sediments filling the valley preserve a complex system of interbedding silts and clays containing abundant fragments of limestone and faunal material. Although a small number of bones were found in articulated position, the material appears to be in a jumbled context, perhaps as a result of slumping or solifluction from above. Even during the early phases of fieldwork, the great abundance of mammoth remains was readily visible. The presence of a cold period fauna including mammoth and woolly rhinoceros along with the predominance of loessic sediments points strongly to an accumulation during a cool phase of the Pleistocene. The lack of a clear geostratigraphic markers forces the use of biostratigraphy, cultural stratigraphy and radiometric dating for assessing the age of the deposits. Several lines of evidence including a series of ESR dates suggest a probable age within the penultimate glaciation (Rink *et al.* n. d.).

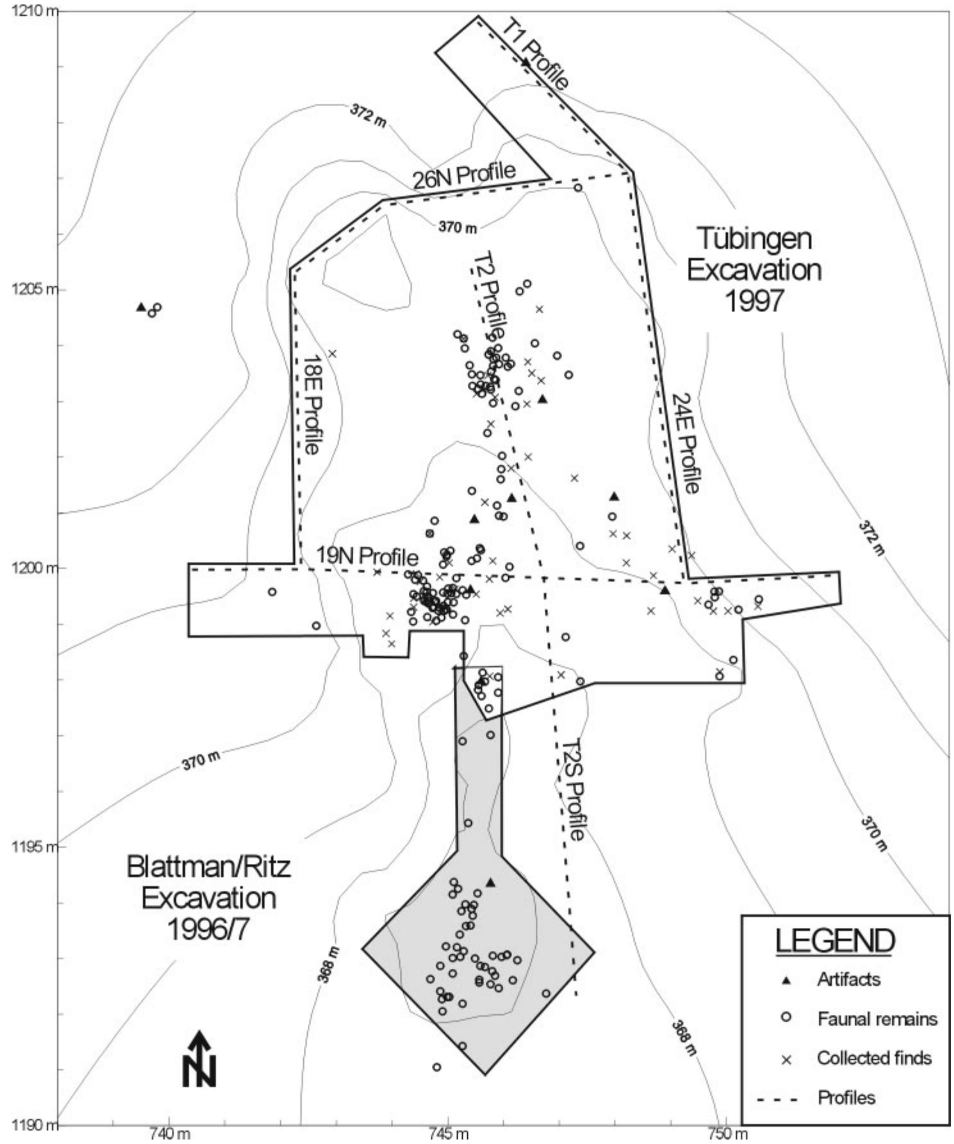

Fig.1 - Bollschweil. Topographic map of the excavation showing the location of faunal and lithic finds.

Fig.2 - Bollschweil. Overview of the excavation looking toward the northwest, October 1997.

Fig.3 - Bollschweil. 24E Profile showing coarse limestone debris and faunal remains, October 1997.

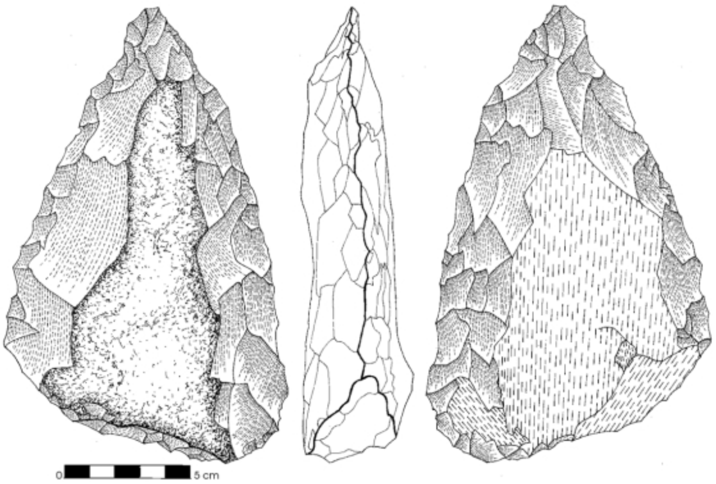

Fig.4 - Bollschweil. Amphibolite handaxe.

3. Lithic Artifacts

The finds from Bollschweil include a dozen lithic artifacts of the following raw materials: chert, quartz, quartzite, amphibolite and siliceous slate (Fig. 4). The poor excavation conditions in the jumble of sediment, bone and limestone rubble, and the lack of a large sample of waterscreened sediment hindered the recovery of lithic artifacts.

Two finds are of typological importance. One piece is a ventrally retouched side scraper of Jurassic chert; the other is a large handaxe of amphibolite (Conard & Kandel 1999; Conard & Blattmann 2000). Typologically, the side scraper, though well documented in earlier and later periods, would most likely belong to the Middle Paleolithic. The cultural assessment of handaxe-bearing assemblages touches on several complex issues. While handaxes are the most important form of the Acheulean, in Germany handaxes are fairly common in the Middle Paleolithic as defined by Bosinski (1967). In southern Germany in particular, bifacially worked artifacts including diverse handaxe forms persist throughout much of the Würmian glaciation. Thus there is no sound basis for distinguishing Lower and Middle Paleolithic assemblages based solely on the presence or absence of handaxes (Conard & Fischer 2000).

4. Faunal Remains

At present the faunal remains from the excavations of the University of Tübingen and from E. Blattmann’s collection are available for study. An unknown amount of material from the Ritz collection is not yet available for study. The combined Blattmann and Tübingen collections include 423 specimens of macro-mammalian fauna, of which 299 pieces could be identified to the level of genus or species (Tab. 1, Fig. 5). These include the remains of mammoth, horse, large bovid, woolly rhinoceros, red deer and bear in descending order of abundance. Many other remains could be placed in general size classes.

While mammoth is by far the best represented species, horse, large bovid, woolly rhinoceros and red deer are represented by 28, 22, 14 and five specimens respectively. The remains of horse represent at least three individuals and are characterized mainly by dentition and distal hind limb elements. Axial skeletal remains are lacking in the sample. Based on the teeth, most of the animals in the death assemblage were young adults. The large bovid assemblage includes remains from at least two animals and shows a very different representation.

With the exception of two distal limb bones and a rib fragment, all the specimens are either

Tab.1 - Bollschweil. Summary of the faunal remains from E. Blattmann's and the University of Tübingen's

Species	NISP	%NISP
Ursus sp.	1	0,2
Mammuthus primigenius	229	54
Coelodonta antiquitatis	14	3,3
Mammoth-/Rhino-sized	17	4
Equus sp.	28	6,6
Bos/Bison	22	5,2
Bovid/Equid-sized	5	1,2
Cervus elaphus	5	1,2
Unidentified	102	24
Total	423	100

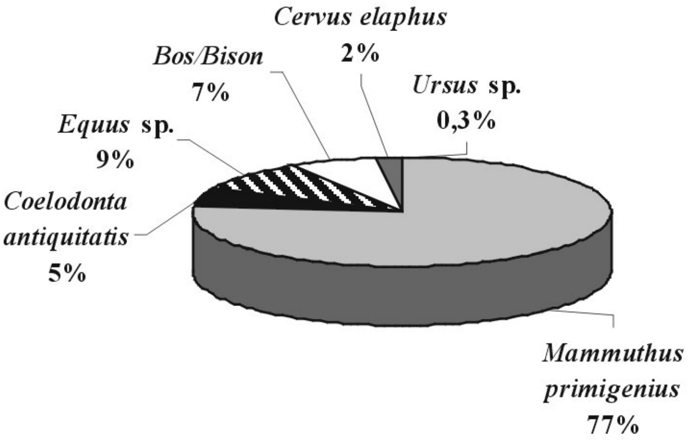

Fig.5 - Bollschweil. Relative abundance of macro-mammalian taxa based on NISP.

cervical vertebrae, pieces of horn core or other cranial fragments, including dentition. Woolly rhinoceros is represented by at least one individual. Other than a metatarsus and two long bone fragments, only teeth and tooth fragments have been documented. The five specimens from red deer include only antler, dental and cranial material. Bear is represented by a complete radius.

The assemblage of mammoth remains includes 229 specimens and forms 77% of the identified specimens and a still higher portion of the assemblage on the basis of weight. There is little doubt, that the majority of the unidentified very large (mammoth or rhino) size class remains are also from mammoth. With this comparatively large assemblage more can be said about the body part representation and age profile of this species. The assemblage includes the remains of at least 6 individuals based on maxillary molars. Tusks, mandible and humerus are also well-represented with MNEs of 3 (Fig. 6). Axial skeletal remains and limb bones are fairly well-represented.

Although foot bones and non-cervical vertebrae are underrepresented, the assemblage

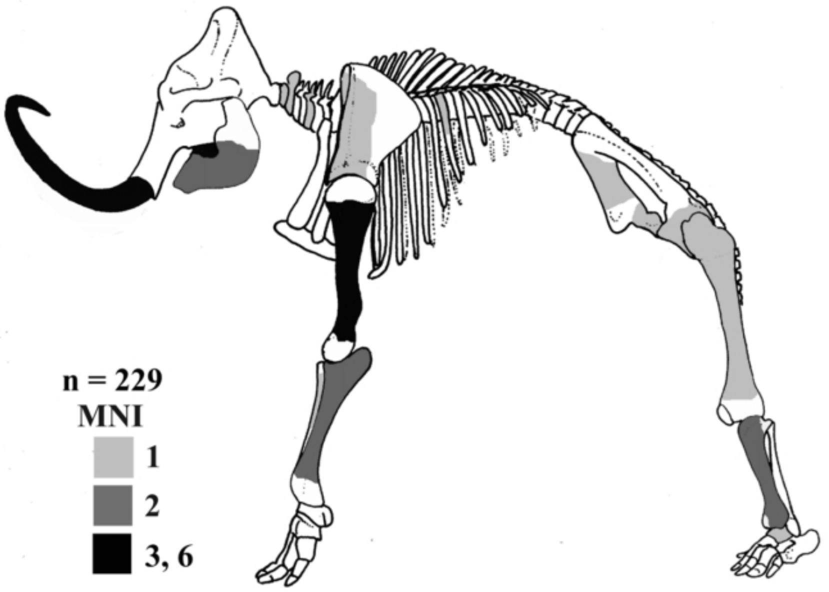

Fig.6 - Bollschweil. Body part representation of *Mammuthus primigenius*. Note that MNI of 6 refers to molars.

appears to reflect the remains of complete animals that either died in the gully or slid into the gully from the higher-lying surroundings. Among the teeth and dental fragments, 16 teeth could be aged using Haynes' (1991) criteria. The age classes 0-12 (n = 3), 13-24 (n = 9) and 37-60 (n = 4) African Elephant Years (AEY) are present, with the young adults in the range from 13-24 AEY best represented among both the maxillary and mandibular teeth. The mammoth finds preserve no clear signs of modification by humans or carnivores, but the relatively poor preservation hinders the identification of such features.

5. CONCLUSIONS

Bollschweil is the only open-air archaeological site in southwestern Germany characterized by an abundance of mammoth remains. The site probably formed during one or more cultural and sedimentary events during the penultimate glaciation. The occurrence of lithic artifacts with a rich faunal assemblage in a relatively small area of excavation suggests that hominids contributed to the faunal accumulation. However, in the absence of conclusive arguments for predation or butchery by hominids, Bollschweil provides tantalizing indications, but certainly no proof, of Neanderthals hunting mammoths on the edge of the Black Forest. While ever more evidence for successful hunting by archaic European hominids accumulates (Conard & Prindiville 2000; Gaudzinski & Roebroeks 2000), the role of elephants in Paleolithic economies remains elusive (Haynes 1991). Only in remarkable settings such as Lehringen (Thieme & Veil 1985) and Gröbern (Mania *et al.* 1990) has it been possible to establish a causal link between the artifacts and the proboscidean skeletal remains. Finally in the southern German context, Bollschweil serves to remind researchers that many new discoveries are still to be made outside the region's many caves, if the necessary resources can be made available to pursue this line of research.

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7. REFERENCES

Bosinski, G. 1967. *Die mittelpaläolithische Funde im westlichen Mitteleuropa*. Fundamenta 4: Cologne: Böhlau Verlag.

Conard, N.J. & Kandel, A. 1999. Die neuen Ausgrabungen in Bollschweil, Kreis Breisgau-Hochschwarzwald – ein mittelpaläolithscher Fundplatz mit Mammutresten. *Archäologische Ausgrabungen in Baden-Württemberg* 1998: 35-40.

Conard, N.J. & Blattmann, E. 2000. Ein Faustkeil aus Bollschweil, Lkr. Breisgau-Hochscharzwald. *Archäologische Nachrichten aus Baden* 63: 3-7.

Conard, N.J. & Fischer, B. 2000. Are there recognizable cultural entities in the German middle paleolithic? In A. Ronen & M. Weinstein-Evron (eds.), *Yabrudian and Micoquian: towards modern humans 400-50 kya*: 7-24. Oxford: Archaeopress.

Conard, N.J. & Prindiville, T.J. 2000. Middle palaeolithic hunting economies in the Rhineland. *International J. Osteoarchaeology* 10: 286-309.

Gaudzinski, S. & Roebroeks, W. 2000. Adults only. Reindeer hunting at the middle palaeolithic site Salzgitter Lebenstedt, northern Germany. *Journal of Human Evolution* 38: 497-521.

Haynes, G. 1991. *Mammoths, mastodonts & elephants: biology, behavior, and the fossil record*. Cambridge: Cambridge University Press.

Mania, D., Thomae, M., Litt, T. & Weber, T. 1990. *Neumark-Gröbern. Beiträge zur Jagd des mittelpaläolithischen Menschen. Publication of the Landesmuseum für Vorgeschichte Halle* 42. Berlin: Deutscher Verlag der Wissenschaft.

Rink, J, Kandel, A.W. & Conard, N.J. n.d. ESR geochronology & geology of the open-air deposits in Bollschweil, Germany. Manuscript available from senior author.

Thieme, H. & Veil, S. 1985. Neue Untersuchungen zum eemzeitlichen Elefanten-Jagdplatz Lehringen, Lkr. Verden. *Die Kunde* 36: 11-58.

Finds of Proboscidean remains in the territory of the Southern Urals region

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SUMMARY: All published materials about fossil elephants remains from the Southern Fore-Urals region (Russia) are presented in a short review. Finds of fossil elephants are of the Pliocene-Pleistocene age and belong mainly to alluvial deposits. At present more than 50 localities with remains of fossil elephants are known. Half of all finds belong to *Mammuthus primigenius* Blumenbach, remains of *Mammuthus chosaricus* Dubrovo, *Mammuthus trogontherii* (Pohlig) are less numerous. Finds of *Archidiskodon meridionalis* (Nesti), *Archidiskodon gromovi* Garutt et Alexeeva, *Mammut borsoni* (Hays), are rare.

1. INTRODUCTION

The great bulk of Proboscideans remains was found in the flat territory of the Fore-Urals. In the mountain part, bones of fossil elephants often occur in caves during archaeological excavations and sometimes in river terrace deposits. On the eastern slope of the Southern Urals bones finds are rare, but this is related to the absence of data: during last 30 years there was no the information about finds (Fig. 1).

2, INFORMATION AND PUBLICATIONS

2.1 Information about finds

As a rule, inhabitants convey news about bones finds. In accordance with experts estimation such cases may occur 10-15 times per year, in 3-4 cases bones are delivered to the museums network of the Bashkortostan Republic and only in 1-2 cases finds may be identified by specialists-paleontologists.

2.2 Publications and studing

So far in geological literature information about more than 50 finds of bones of fossil elephants has been published, which were determined by paleontologists: E.I. Belajeva (1948; Nikiforova 1940, 1948;. Yakchemovich 1965), Plotnikov, Dubrovo (Yakchemovich 1965; Yakchemovich 1965), Yakchemovich (1965), Gromov (1940, 1941; Yakchemovich 1965; Yakchemovich 1965), Garutt (1972; 1985; Garutt, Shokurov & Yakchemovich 1977; Yakchemovich *et al.* 1983; Garutt & Urbanas 1988), Kozhamkulova (Kozhamkulova & Ismagilova 1990), Urbanas (Garutt & Urbanas 1988), Vangengeim (Yakchemovich 1965; V. Yakchemovich 1965), Kosincev.

3. FINDS AND LOCALITIES

3.1 Mammuthus primigenius (Blumenbach)

Half of all finds belongs to *Mammuthus primigenius*. Bones material presented by isolated teeth, fragments of tusks, vertebrae, bones of extremities, pelvic bones, shoulder blades, occasionally fragments of scale and ribs. Local people gather such materials and then transfer it to different museums for storing. Often exact places of finding are unknown and in our opinion bones were collected from rivers beaches. As in the Fore-Urals in the basins of Belaya, Kama, Ufa Rivers and their tributaries. 18 such localities are known. On the territory of the eastern slope of the Southern Urals bones located in the modern alluvium of Ui, Khudolaz, Ural Rivers and their tributaries are known from 4 localities. Finds of whole skeletons are rare. An incomplete mammoth skeleton is known from Tabulda. In Novobelokatai locality only fragments of mammoth thighbone are known. Only 4 localities with isolated mammoth bones *in situ* are known, which are Novikovka, Krasnousolsk, Pavlovka and Kabakovo – all of them from terrace deposits.

3.2 Mammuthus chosaricus Dubrovo

Only five finds of *Mammuthus chosaricus* remains are known. Finds were *in situ* at Orjebash, Klimovka, Sultanaevo, Sukharevka. Whole skeletons were found at Orjebash and Suharevka. At Klimovka and Sultanaevo only isolated teeth were found. One tooth was discovered in alluvium of the Belaya River near the Gornova locality.

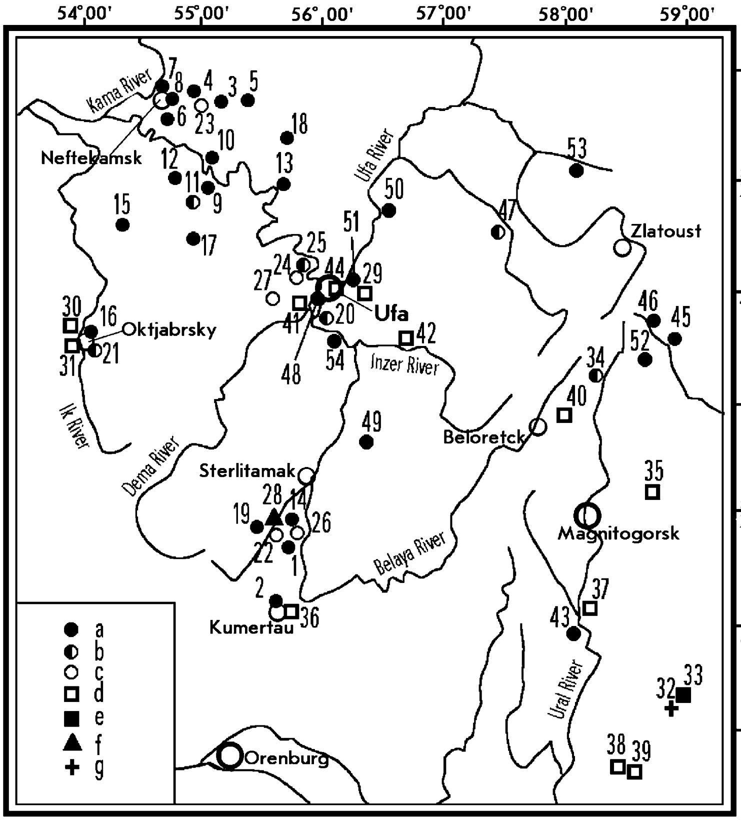

Fig.1 - Location of the sites with Proboscidean remains on the territory of the Southern Urals region
Legenda:

Species: a - *Mammuthus primigenius* (Blumenbach); b - *Mammuthus chosaricus* Dubrovo; c - *Mammuthus* sp.; d – *Mammuthus trogontherii* (Pohlig); e - *Archidiskodon meridionalis* (Nesti); f - *Archidiskodon gromovi* Garutt & Alexeeva; g - *Mammut borsoni (*Hays).

Localities: 1 - Meleuz; 2, 36 - Kumertau; 3 - Kaltasy; 4 - Muzyak; 5 - Nikolsk; 6 - Arlan; 7 – Nikolo-Berezovka; 8 - Koreevo; 9 - Dyurtyuly; 10 - Angasyak; 11 - Semiletka; 12 - Verkhneyarkeevo; 13 - Birsk; 14 – Salavat; 15 - Bakaly; 16 - Oktyabrsky; 17 - Chekmagush; 18 - Buraevo; 19 - Tabulda; 20 - Nagaevo; 21 - Tukmakly; 22 - Sukharevka; 23 - Orjebash; 24, 25 - Gornova; 26 - Klymovka; 27 - Sultanaevo; 28 - Mustafino; 29 - Mynzytyarovo; 30, 31 - Oktyabrsky; 32, 33 - Kvarkeno; 34 – Berezovaya Roscha; 35 – Kisil-Chilik; 37 - Proletarka; 38, 39 - Shuburtau; 40 - Mindyak; 41, 44, 48 - Ufa; 42 - Inzer; 43 – Khudolaz; 45 - Malaya Kulakhta; 46 - Polyakovka; 47 - Kluchevskaya cave; 49 - Krasnousolsk; 50 - Pavlovka; 51 - Klyashevo; 52 - Ilchino; 53 – Novobelokatai; 54 - Kabakovo.

*3.3 Mammuthus trogontherii (*Pohlig)

Seven finds of *Mammuthus trogontherii* are known. Three find spots are located on the eastern slope of the Southern Urals: Proletarka, Shuburtau, Kyzyl-Chilik (in situ) and lifting material from the Mindyak locality. In the Southern Fore-Urals finds of isolated teeth of *Mammuthus trogontherii* occur in the overdeeping alluvium of Belaya and Big Ik rivers, at Ufa and Oktyabrsky. One locality is on the Inzer River and near Kumertau Town where a tooth was found in situ. At Minzityarovo was probably a whole skeleton, but only some bones were extracted: a fragment of the scale base, part of the lower mandible, a fragment of the wright tusk, fore teeth, three heavy damaged vertebrae (thoracic, lumbar, sacral), a fragment of the pelvic bone.

*3.4 Archidiskodon meridionalis (*Nesti)

A single find, i.e. an isolated tooth of *Archidiskodon meridionalis* is known on the territory of the eastern slope of the Southern Urals in the Kvarkeno locality.

3.5 Archidiskodon gromovi Garutt & Alexeeva

One isolated tooth of *Archidiskodon gromovi* was found in the Southern Fore-Urals *in situ* in the Mustafino locality.

*3.6 Mammut borsoni (*Hays)

One isolated tooth of *Mammut borsoni* was found on the eastern slope of the Southern Urals, *in situ* in the Kvarkeno locality.

3.7 Mammuthus sp.

There are some localities with remains of Proboscideans, which were determined as *Mammuthus* sp.: Semiletka, Tukmakly (*in situ*), Gornova, Kluchevskaya cave, Klyashevo (*in situ*).

4. RADIOCARBON DATES

The age of *Mammuthus primigenius* from Tabulda is >34,900 years (LU-1377A). In Novobelokatai locality (Fore-Urals) the age of deposits with fragment of *Mammuthus primigenius* Blumenbach thighbone is 41070±1570 y. (LU-4149).

5. CONCLUSIONS

There is ground to believe that the Quaternary deposits of the region are remains of Proboscideans and rich of that the region is adeguate for the study of Quaternary Proboscidean faunas.

6. REFERENCES

Bashenina, N.V. 1948. *Origin of the Southern Urals relief*. Moscow-Leningrad: Geografgiz (in Russian).

Belajeva, E.I. 1948. About finds of *Elephas (Archidiskodon) meridionalis* Nesti & *Mastodon borsoni* Haus in Chkalovsk region. *Bull. of Quaternary Commission* 12: 7-20 (in Russian).

Garutt, V.E. 1972. Skeleton of the khazar mammoth *Mammuthus* cf. *chosaricus* Dubrovo from Middle Pleistocene deposits of Orja-river (basin of the Kama-river.). In *Questions of the stratigraphy and correlation of the Pliocene and Pleistocene deposits of the Southern and Northern parts of the Fore-Urals* 2: 37-34. Ufa: BFAN USSR (in Russian).

Garutt, V.E. 1985. Skeletal remains of the trogontherium elephants - *Archidiskodon trogontherii* (Pohlig) - from Minzitjarovo section. In *Results of the study of the Quaternary sections with elephants remains in Bashkiria*: 11-15. Ufa: BFAN USSR (in Russian).

Garutt, V.E., Shokurov, A.P., Yakchemovich, V.L. 1977. New Tiraspol fauna locations on the border of the Bashkiria and Tataria. In *Results of biostratigraphical, lithological, and physical investigations of the Pliocene* *and Pleistocene of the Volga-Urals region*: 91-96. Ufa: BFAN USSR (in Russian).

Garutt, V.E., Urbanas, E.V. 1988. The first find of *Archidiskodon gromovi* Garutt et Alexeeva remains in the Bashkirian Fore-Urals. In *Some questions of biostratigrafy, paleomagnetizm and tectonica of the Cenozoic of the Fore-Urals*: 4-16. Ufa: BFAN USSR. (in Russian).

Gromov, V.I. 1941. Mammals remains from the western slope of the Southern Urals. In *Materials about Quaternary deposits of the Bashkiria and Volga region* 2: 75-78. Moscow-Leningrad: Geolizdat (in Russian).

Ismagilova, G.M. 1992. Main finds of large mammals remains in the Bashkirian Fore-Urals and their stratigrapfical significance. In *Fauna and flora of the Cenozoic of the Fore-Urals and some aspects of the magnetostratigraphy*: 93-113. Ufa: BFAN USSR (in Russian).

Kozhamkulova, B.S., Ismagilova, G.M. 1990. *Mammoth fauna of the Bashkiria.* Alma-Ata: VINITI (in Russian).

Nikiforova, K.V. 1940. *Essay of the continental history of the eastern slope of the Southern Urals in the region of the upper reaches of the Tobol and Suunduk rivers. (Transactions of GIN AN USSR* 42, Geol. Ser. 12 (in Russian).

Nikiforova, K.V. 1948. *Continental Mesozoic deposits of the east slope of the Southern Urals*. (*Transactions of GIN AN USSR* 26 (in Russian).

Ozhiganova, O.I. 1941. About terraces of the Ufa-town region. In *Materials about Quaternary deposits of the Bashkiria and Volga region* 2: 93-104. Moscow-Leningrad: Geolizdat (in Russian).

Shokurov, A.P. 1977. Staro-Tukmakly locality of mammals bone in the Bashkiria. In *Results of biostratigraphical, lithological, and physical in-vestigations of the Pliocene and Pleistocene of the Volga-Urals region*: 97-102. Ufa: BFAN USSR (in Russian).

Urbanas, E.V. 1988. Skeleton remains of the mammoth *Mammuthus primigenius (Blumenbach).* In *Results of studying Quaternary sections with elephants in Bashkiria*: 48-54. Ufa: BFAN USSR (in Russian).

Vachrushev, G.V. 1938. Quaternary deposits of the Bashkiria (Southern Urals & Fore-Urals). *Scientific notes of the SGU*. 1, Geol. Ser., 2: 3-58 (in Russian).

Yakchemovich, N.N. 1960. About find of *Parelephas trogontherii* (Pohl.) remains near the Suhailja river. In *Questions of the geology of the eastern part of the Russian platform and the Southern Urals*: 133-138. Ufa: BFAN USSR (in Russian).

Yakchemovich, N.N. 1965. Mammal remains from anthropogen sediments of the Southern Urals. In *Anthropogen of the Southern Urals*: 229-237. Moscow: Nauka (in Russian).

Yakchemovich, N.N. 1966. *Stratigraphy of the Pliocene and Quaternary deposits of the eastern slope of the Southern Urals*. Moscow: MGU (in Russian).

Yakchemovich, N.N. 1976. Stratigraphical location of *Mammuthus chosaricus* Dubrovo finds in the Southern Urals. In *The stratigraphy and correlation of the Pliocene and Pleistocene of the Fore-Urals*: 20-25. Ufa: BFAN USSR (in Russian).

Yakchemovich, V.L. 1958. Quaternary deposits of lower river terraces of the Bashkirian Fore-Urals. In *Cenozoic of the Bashkirian Fore-Urals*. 2, 1. Ufa: BFAN USSR (in Russian).

Yakchemovich, V.L. 1965. Anthropogen deposits of the Southern Fore-Urals. In *Anthropogen of the Southern Urals*: 8-54. Moscow: Nauka (in Russian).

Yakchemovich, V.L., Nemkova, V.K., Suleimanova, F.I. *et al.* 1983. *Fauna and flora of the Pliocene and Pleistocene (Sultanaevo-Yulushevo locality)* 5. Moscow: Nauka (in Russian).

The elephant remains from the Agro Pontino, Latina, Central Italy

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SUMMARY: Numerous gathering spots of Middle to Late Pleistocene fossil vertebrate remains and stone implements are known in the northern Agro Pontino. One of the most productive has been Campoverde, located between Latina and Aprilia, which has yielded remains of several mammals, among which a relatively primitive representative of *Mammuthus primigenius*, with traits recalling somewhat those of *M. trogontherii*, and *Equus hydruntinus*, which altogether suggest a correlation with the isotopic stage 7. In association with vertebrate bones a rich flint industry was collected at the surface. All the artifacts have been made from small flint pebbles and a preliminary examination of the technological and typological characteristics suggest a Lower Palaeolithic age for the lithic industry of Campoverde.

1. INTRODUCTION

The northern part of the Agro Pontino coastal plain (Latina) has contributed rich amounts of vertebrate remains and stone implements, all spanning the Middle to Late Pleistocene. The Middle Pleistocene finds were contained in volcanoclastic deposits mostly referable to the Vulcano Laziale cycle. Numerous significant gathering spots are known; the most oustanding one is that known as Campoverde, located between Latina and Aprilia.

2. SPECIMENS

2.1 Fauna

The wealthy collections of fossil bones from Campoverde were recovered from two gathering spots, respectively CV1 and CV2, exposed by mechanical works for a ditch in an area indicated locally as Campoverde (Mazza *et al.* 1992; Vianello *et al*. 1995). The material had been removed from its original setting by the mechanical works and was found concentrated on the surface; it was therefore not recovered in situ, but very close to its bed of provenance. The CV1 material outnumbered by far that from CV2; the latter in turn provided a deciduous right upper premolar of *Homo* sp. The faunal list includes altogether *Elephas antiquus*, *Mammuthus primigenius*, *Stephanorhinus* spp., *Equus ferus*, *E. hydruntinus*, *Hippopotamus* sp., *Bos primigenius*, *Caprinae* ind., *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, ?*Megaloceros* sp., *Ursus* sp., *Canis* sp. (cf. *C. mosbachensis*), Aves ind., Chelonia ind. (Mazza *et al.* 1992; Vianello *et al.* 1995). Another significant recovery was also the human tooth which exceeds the dimensions of the correspondent deciduous premolars of present-day boys (mesio-distal diameter: 9,4 mm; bucco-lingual diameter: 10,2 ? mm).

E. antiquus remains were also found at another gathering spot, Valloncello, near Cisterna di Latina (Vianello *et al.* 1995). Compared with Campoverde, Valloncello yielded a poorly diversified and poorly represented fauna. Besides the elephant, the faunal list from this locality includes *E. ferus*, *Hippopotamus* sp., *C. elaphus*, *B. primigenius* and *U.* gr. *deningeri-spelaeus*.

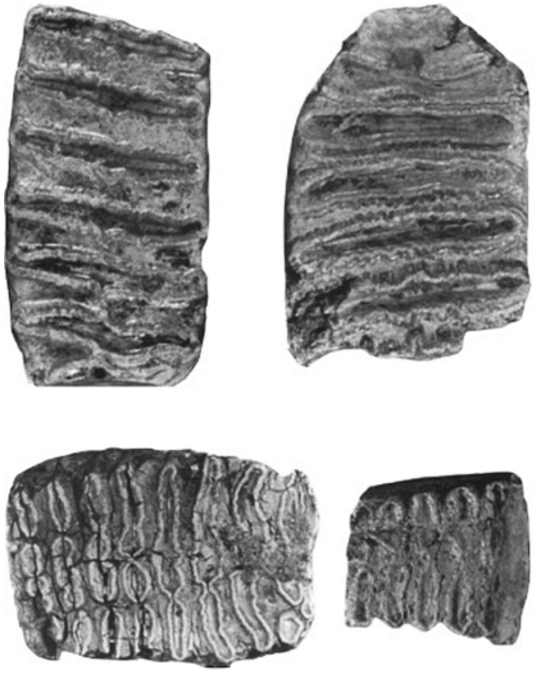

Fig.1 - Top – *Elephas (Palaeoloxodon) antiquus* from Campoverde: two right second upper molars, occlusal view.
Bottom – *Mammuthus primigenius* from Campoverde: left, right third lower molar, occlusal view; right, right (?) lower (?) molar.

2.2 Lithic industry

The collection of stone artifacts from Campoverde (Vianello *et al.* 1995; La Rosa 1998) is the result of an unsystematic survey by local amateurs and totals (present number) 245 specimens (95 cores and core-like elements, 38.8%; two unretouched flakes, 0.8%; 148 tools, 60.4%). They were all obtained from small flint pebbles, rarely more than 5-6 cm. long; this explains the very high frequency of the cortex on the flakes and the small to very small dimension of the tools. Like in several other Lower Palaeolithic sites of Latium, the weathering patinae are not homogeneous: only 9.4 % of the specimens are fresh, while 43.5 % show a brownish polished and shiny patina and have sharp ridges, 42.7 % display the same brownish polished patina but with slightly blunt ridges and 4.4 % have slightly blunt ridges and no patina at all. In spite of their different physical aspect, the tools do not show any technical or typological differences. Their main characteristics are the following: strong incidence of cortex; predominance of cortical and flat butts; complete absence of Levallois technique; presence of bipolar technique and centripetal cores; almost complete absence of unretouched flakes; high amount of carinate elements; particular abundance, among the tools, of the group of the denticulates, often microlithic (42.8%), followed by sidescrapers (21.1%), borers (8.8%), retouched flakes (7.5%), endscrapers (6.8%) and choppers (6.1%). This assemblage shares affinities with various Lower Palaeolithic industries of Latium, such Malagrotta (Cassoli *et al.* 1982) and La Polledrara di Cecanibbio (Anzidei & Arnoldus Huyzendveld 1992) , chronologically referred to the second half of the Middle Pleistocene.

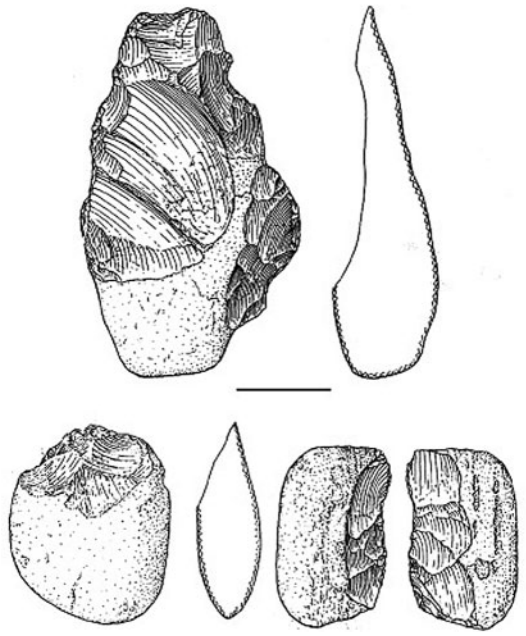

Fig.2 - Campoverde – top: denticulate on residual core; bottom: distal monofacial and lateral bifacial choppers (scale bar: cm).

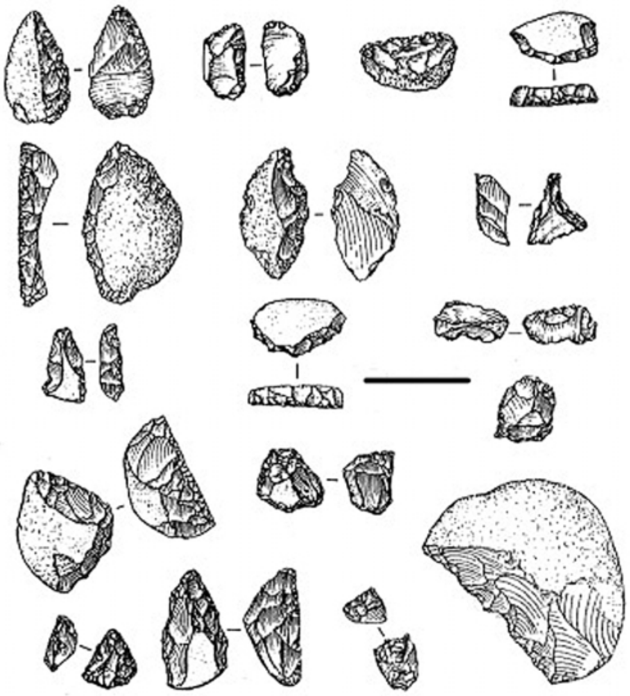

Fig.3 - Campoverde – lithic implements.

3. CONCLUSIONS

The Campoverde *M. primigenius* is a relatively primitive representative, with traits recalling somewhat those of *M. trogontherii*. These transitional forms, called *M.* "*chosaricus*"/*M. primigenius* (Palombo 1995), have great stratigraphical importance, since they characterize the Holsteinian (isotopic stage 9) of the Netherlands (Kolfschoten 1981, 1985) and of the British Isles (Sutcliff 1985). The lack of precise information on the stratigraphical provenance of the material unfortunately prevents to ascertain if the co-occurrence of this proboscidean with *E. antiquus* is effective or rather the result of an artificial mixing of the specimens. Co-existing *M. trogontherii/M. primigenius* and *E. antiquus* elephants are actually reported from central and northern Europe and characterize the Holsteinian and especially its transition to the Saalian Complex (isotopic stage 8÷6). The fauna from Campoverde is altogether coherent from the chronostratigraphical viewpoint. Incidentally, if the dating of the fauna should be confirmed by future research, the presence of *E. hydruntinus* in transitional Holsteinian/Saalian levels (isotopic stage 7) would be the earliest known occurrence of this taxon in Italy.

4. ACKNOWLEDGEMENTS

The authors are grateful to T. Kotsakis for his precious suggestions.

5. REFERENCES

Anzidei, A.P. & Arnoldus Huyzendveld, A. 1992. The lower Palaeolithic site of La Polledrara di Cecanibbio (Rome, Italy). *Papers of the Fourth Conference of Italian Archaeology:* 142-153. London: Accordia Research Center.

Cassoli, P.F., De Giuli, C., Radmilli, A.M., Segre, A.G. 1982. Giacimento del Paleolitico inferiore a Malagrotta (Roma). *Atti della XXIII Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria:* 531-549.

Kolfschoten, Th. van 1981. On the Holstenian? and Saalian Mammal Fauna from the Ice-pushed Ridge near Rhenen (The Netherlands). In Ruegg G.H.J., Zandstra J.G. (eds.), *Geology and archeology of Pleistocene deposits in the ice-pushed ridge near Rhenen and Veenendaal*, Geol. Surv. Netherlands, Meded. Rijks Geol. Dienst., 35-2/7: 223-251.

Kolfschoten, Th. van 1985. The Middle Pleistocene (Saalian) and Late Pleistocene (Weichselian) mammal faunas from Maastricht-Belvédère (Southern Limburg, The Netherlands). In H.W.J. van Ameron (ed.) *Maastricht-Belvédère: stratigraphy, palaeoenvironment and archaeology of the Middle and Late Pleistocene deposits*, Meded. Rijks. Geol. Dienst 39-1: 45-74.

La Rosa, M. 1998. The earliest Palaeolithic industries of the Agro Pontino (Latina, Central Italy). *Papers from the EAA third Annual Meeting at Ravenna 1997. Volume I: Pre- and Protohistory. BAR International Series* 717: 6-10.

Mazza, P., Moggi-Cecchi, J. & Rustioni, M. 1992. Vertebrate remains from Campo Verde, Latium, Central Italy. *Antropologia Contemporanea* 15: 65-83.

Palombo, M.R., 1995. Gli elefanti del Pliocene superiore e del Pleistocene dell'Italia centrale peninsulare: alcune considerazioni. *Studi Geologici Camerti, volume speciale* B (1994): 447-457.

Sutcliff, A.J. 1985. *On the track of Ice Age mammals*. Dorchester: Henry Ling Ltd. Dorset Press.

Vianello, F., La Rosa, M., Mazza, P., Moggi-Cecchi, J., Rustioni, M. 1995. Palaeolithic from the volcanoclastic deposits of the Agro Pontino, Latium, Central Italy. *Quaternaria Nova* 5: 7-22.

The Middle and Late Pleistocene Mammoth remains from Hanhoffen (Bas-Rhin, France)

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SUMMARY: The paleontological study of the Proboscideans of Hanhoffen was performed on 642 cheek teeth. On one hand, we had to determine the different species, on the other hand we were interested in the possible causes of death. The analysis of the mortality profile obtained on the population of *Mammuthus primigenius* allows us to retain the hypothesis of a massive mortality of natural origin.

1. INTRODUCTION

The site is located on a Quaternary terrace of the Rhine Valley, in Alsace (eastern France), approximately 30 km from Strasbourg. The gravel pits of Hanhoffen delivered a lot of Elephantinae remains that represent almost 50% of the bony vestiges, and other big herbivores, which were excavated by workers. Unfortunately, nobody noted the stratigraphic position of the various assemblages.

This study is that of a private collection (assembled by Georges Rocques), which is now stored at the Prehistoric Museum of Arras in northern France.

Our attention particularly focused on the teeth and fragments of them, which totalise a third of the Proboscidean remains; one molar providing a great deal of information about the animal, such as its evolution degree or its death age.

2. DETERMINATION OF THE ELEPHANTIDAE PRESENT AT HANHOFFEN

Very detailed measurements of each molar and the determination of their position in the jaw and the dental series, allow us, afterwards, to determine the species to which the animal belongs. Thus, the table 1 shows, in part, the statistic methods employed in order to differentiate the five species of Proboscidean. The main data we can take into account are the lamellar frequency index (F), the number of enamel loops measured on 10 cm of the occlusal surface, the enamel thickness (e, noted in mm), as well as the morphology of these last ones, marked or not by the specific presence of a sinus.

Indeed, the systematic presence on the enamel loops of a loxodont sinus (clear fold of enamel) characterizes the Elephant (*Palaeoloxodon antiquus*) and differentiates it easily from the Pleistocene Mammoths. Moreover, an Elephant tooth is less wide than a Mammoth one.

If we observe the last molars, the M3, we can see that the overall evolving tendency of the Mammoths line is to a reduction of the enamel thickness, accompanied by a more important lamellar frequency. This increase in the abrasive function of the molars (Fig. 1) allows Elephantidae to have a more varied alimentary diet, mainly composed of boughs and numerous graminaceous for *Mammuthus primigenius*, the most advanced Mammoth.

Tab.1 - Extract of the measures employed in order to determinate the species of Proboscidean at Hanhoffen (with "u"= wear).

Piece	Specie	Position	N	Nd	Nf	Li	l	H	h	u	e	F
HAH 2179	*M.primigenius*	M3 inf. d.	19	°°18x-		252	71			B4	1,6	8,5
HAH 2196	*M.primigenius*	M3 inf. d.	23	22-	10	276	81	132	163	B2	1,6	11
HAH 2207	*M.primigenius*	M3 inf. d.	23	22x	11?		98	150	153	B3	1,5	8,5
HAH 2238	*M.primigenius*	M3 inf. d.	22	°°21x	13	288	75	122	163	B3	1,5	9
HAH 2261	*M.primigenius*	M3 inf. d.	14	14-	8		85	128	151	B3	1,7	8
HAH 2265	*M.primigenius*	M3 inf. d.	20	°°20-	13		91	130	143	B3	1,7	8,5
HAH 2315	*M.primigenius*	M3 inf. d.	16	°°16-	7		85	138	162	B2	1,5	9,5
HAH 2357	*M.primigenius*	M3 inf. d.	12	-11x	6		74			B4	1,9	12
HAH 2366	*M.primigenius*	M3 inf. d.	22	°°21x	16	306	90	134	149	B4	1,3	8
HAH 2518b	*M.primigenius*	M3 inf. d.	22	°°21x	17	270	80	123	154	C	2	9
HAH 2600	*M.primigenius*	M3 inf. d.	18	18-	0		84	151	180	A2	1,8	10
HAH 2625	*M.primigenius*	M3 inf. d.	16	16x	15	237	75	113	151	C	1,8	8,5
HAH 2632	*M.primigenius*	M3 inf. d.	8	°°8-	8					D4	1,7	8
HAH 2028	*M.primigenius*	M3 inf. g.	22	°°22-	8		73	132	181	B2	1,4	11
HAH 2034	*M.primigenius*	M3 inf. g.	23	23-	13		100	151	151	B3	1,7	8
HAH 2092	*M.primigenius*	M3 inf. g.	15	-15-	8		81	143	177	B	1,6	10
HAH 2163	*M.primigenius*	M3 inf. g.	18	18-	15		79	137	173	B4	1,5	10
HAH 2177	*M.primigenius*	M3 inf. g.	23	°°23-	11		87	149	171	B3	1,7	10
HAH 2214	*M.primigenius*	M3 inf. g.	7	6x	4		80	108	135	C	2,2	10
HAH 2250	*M.primigenius*	M3 inf. g.	16	-16-	4		84	116	138	B3	1,6	12
HAH 2254	*M.primigenius*	M3 inf. g.	22	°°22-	6		73	116	159	B2	1,3	11
HAH 2277	*M.primigenius*	M3 inf. g.	21	-20x	14	271	69	120	174	B2	1	9,5
HAH 2281	*M.primigenius*	M3 inf. g.	25	°°24x	11	265	66	137	208	B2	1,5	12
HAH 2288	*M.primigenius*	M3 inf. g.	23	x21x	9	265	80	136	170	B2	1,2	12
HAH 2373	*M.primigenius*	M3 inf. g.	19	-19-	7		80	117	146	B2	1,1	12
HAH 2448	*M.primigenius*	M3 inf. g.	21	-21-	14		66	127	192	B3	1,2	12
HAH 2449	*M.primigenius*	M3 inf. g.	20	19x	15	279	90	136	151	B3	1,5	9
HAH 2582	*M.primigenius*	M3 inf. g.	21	-21-	12		74	111	150	B3	2	9,5
HAH 2458	*M.primigenius*	M3 inf. g.	24	°°23x	13	295	92	126	137	B3	1,8	8,5

3. HANHOFFEN ELEPHANTINAE

3.1 Elephantinae taxa present in the sample

Five species of Pleistocene Proboscidean are present at Hanhoffen, however the representation of each one is not the same (Fig. 2). On the one hand, *Mammuthus primigenius* groups about two thirds of the specimens, while *Mammuthus trogontherii* represents only a fifth. On the other hand, *Mammuthus "intermedius"*, which gathers morphological and biometric characteristics of the two previous species, represents only a tenth of the total. Lastly, the oldest one, *Mammuthus meridionalis*, as the Elephant (*Palaeoloxodon antiquus*) are in the minority. The minimum number of Elephantinae in Hanhoffen, in frequency, is about 98, with 56 for *Mammuthus primigenius*, 11 for *Mammuthus "intermedius"* and 20 for *Mammuthus trogontherii*.

3.2 Description of the mortality profile of the Mammuthus primigenius *of Hanhoffen.*

Here, we have particularly paid attention to *Mammuthus primigenius*, the most represented Elephantidae in Hanhoffen, in order to draw the mortality profile of its population. To that effect, it was necessary to define some age groups, by taking into account the position of each tooth in the cheek teeth series, as well as its worn level (Beden 1979; Germonpré 1993), the whole correlated with the model of extaut elephants (Craig *in* Haynes 1991).

The mortality profile (Fig. 3) presents a dominant group which corresponds to 22-35 years old adults, with nearly 40% of dead individuals on the total strength, followed by the group of the young adults (12-22 years old) with a representation of almost 25%.

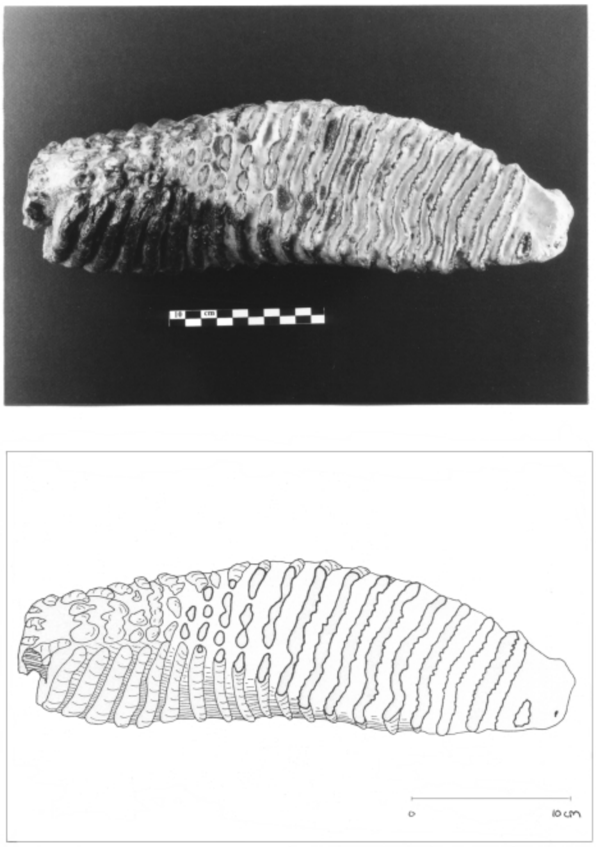

Fig.1 - Right lower M3 of *Mammuthus primigenius* (HAH 2366). Collection of Georges Rocques. Photograph taken by Marie-Claire Mussault. Tooth drawn by Sophie Louguet.

3.3 Hypothesis on the possible causes of death

First of all, the taphonomic analysis of bones, carried out by P. Auguste[1], shows that no mark of human activity (like cuts) is present among the 1361 bones remains. Therefore, we can say that hominids do not seem to have practised hunting at Hanhoffen.

Moreover, we must specify that the population of *Mammuthus primigenius* is not regarded as homogeneous, so its mortality profile, obtained from more than 400 dental remains, shows the dominant trend noticeable on a long time.

This profile does not show an important percentage of very young individuals, as it would be the case in such models as selective hunting or catastrophic massive death assigning a population in extension. Also, the oldest individuals are not dominant, which means that the whole mnnnpopulation of Elephantidae is not dead of old age, every age group being represented on the site.

This age profile is rather similar to the "model C" defined by Haynes (1987), where the populations were probably declining. Then, we can also add, several individuals who died of old age. However, as the bones and dental remains have been collected over a very long periods, we speak here of a general tendency. Consequently, Proboscideans do not seem to have been the victims of a single phenomenon, it would rather result from several factors, which, added or considered distinctly, would have carried out the individuals to their loss. Among them, the most probable are the diseases, the accidents (fall, drowning, etc…), malnutrition (worsened by the drought), the old age, and often predators, others that Hominids

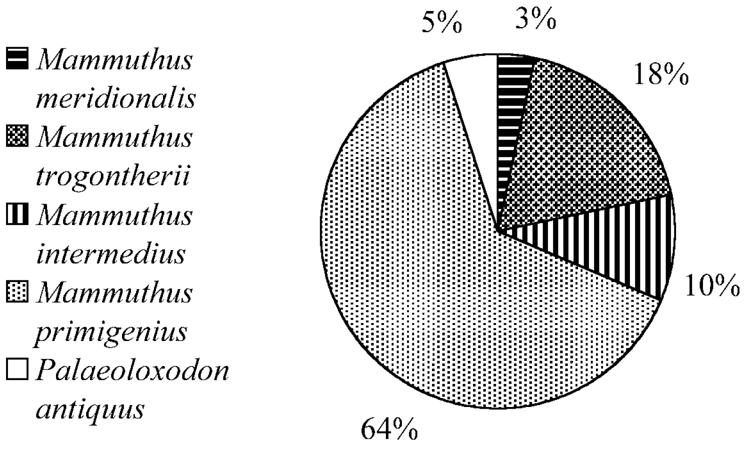

Fig.2 - Percentage of various species of Pleistocene Proboscideans at Hanhoffen.

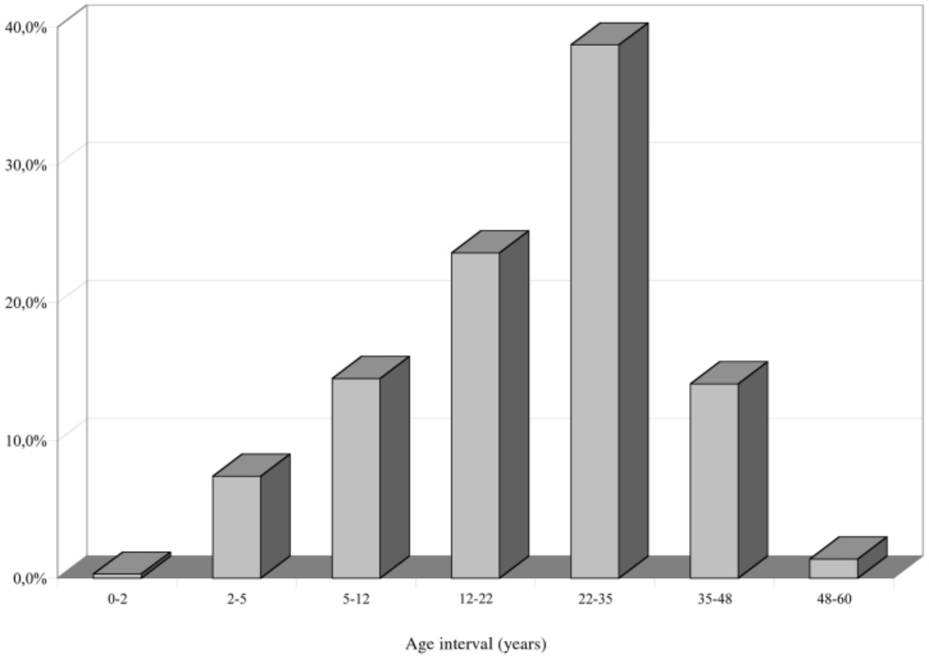

Fig.3 - Mortality profile of *Mammuthus primigenius* at Hanhoffen.

in the case of Hanhoffen, since hunting does not seem to have been practised there.

Moreover, the mortality rise was certainly influenced by climatic deteriorations. Indeed, in Winter, when water and food were running out, competition between herbivores, which consequently were concentrated in valleys, was increased. So, some individuals could sometimes suffer of malnutrition. Only the strongest animals could survive, while the weakest became the prey of carnivores. However, in the case of Hanhoffen, we do not know if the few traces of bites observed on the bones are attributable to predators, or more simply if they are marks of scavengers.

Besides, we can explain the relatively strong percentage of mortality of the 12-22 years old individuals in Hanhoffen if we compare the fossil species with the current ones. Indeed, African Elephants, for example, reach their sexual maturity between 8 and 14 years, while for the Elephants living in Asia, puberty occurs between 8 and 10 years. Two or three years later, the young male leaves the group, and lives alone for some time, which makes it more vulnerable (Haynes 1988; Laws 1966).

4. CONCLUSION

The mortality profile obtained from representatives of *Mammuthus primigenius* would correspond to a massive death of natural origin affecting a declining population. Consequently, the hominids of the time do not seem to have practised hunting in Hanhoffen.

At last, if we consider the evolving stages of the different species of Elephantinae, we can attribute the faunal remains of that site to a stratigraphic sequence whose minimal extension would be from the Cromerian, since is present here an advanced form of *Mammuthus meridionalis*, such as that found in Wissant in the north of France (Bouchud 1963), until the end of Weichselian, depending on the presence of a very advanced *Mammuthus primigenius*.

5. REFERENCES

Beden, M. 1979. *Les Eléphants d'Afrique Orientale: systématique, phylogénie, intérêt biochronologique*. Thèse de la Faculté des Sciences Universitaires de Poitiers. 2 vol.

Bouchud, J. 1963. Etude sommaire de la molaire d'Eléphant trouvée à Wissant. *Revue anthropologique*: 83-85.

Germonpré, M. 1993. Taphonomy of Pleistocene mammal assemblages of the Flemish Valley, Belgium. *Bulletin de l'institut royal des sciences naturelles de Belgique*. *Sciences de la Terre* 63: 271-309.

Haynes, G. 1987. Proboscidean die-offs and die-outs: Age profiles in fossil collections. *Journal of Archaeological Science*. 14 (6): 659-668.

Haynes, G. 1988. Longitudinal studies of African elephant death and bone deposits. *Journal of Archaeological Sciences* 15: 131-157.

Haynes, G. 1991. *Mammoths, mastodonts and elephants. Biology, Behavior, and the fossil record.* Cambridge University Press.

Laws, R.M. 1966. Age criteria for the African elephant, *Loxodonta africana. East African Wildlife Journal* 4: 1-37.

Louguet, S. 2000. *Étude des molaires d'Éléphantidés de Hanhoffen (vallée du Rhin) datant des pléistocènes moyen et supérieur. Caractéristiques biométriques, paléontologiques, taphonomiques et biochronologiques.* Mémoire DEA Université des Sciences et Technologies de Lille. (unpublished).

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Spanish Pleistocene Proboscidean diversity as a function of climate

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SUMMARY: Around 0.9 Ma ago, the 100 ka Milankovitch cycles forced global climate, causing glaciations, and created new ecological niches. It is at this time that *Elephas antiquus* arrived in Europe and occupied the temperate environments, while *Mammuthus* became increasingly adapted to cold environments.

1. INTRODUCTION

Fossil proboscideans have been among the first fossils that lead to palaeoclimatic interpretations. Interest focussed mainly on their value as a indicators of glacial and interglacial conditions in central Europe. Two genera and four species occur in the Pleistocene of western and central Europe: *Mammuthus meridionalis, M. trogontherii*, *M. primigenius*, and *Elephas antiquus*. The species of *Mammuthus* have historically been seen as a lineage, but present opinions are more inclined to see them as subsequent species, that arrived by dispersal (Lister 1996).

One of the first occurences of *Mammuthus meridionalis* in western and central Europe is from Montopoli, in sediments overlying the top of the Gauss Epoch (Azzaroli 1977), suggesting an age for the entry of some 2.6 Ma. One of the last occurrences of the species is in Voigtstedt (Von Koenigswald & Heinrich 1999), a locality believed to be corelative of OIS 17 (Van der Made in press). *Mammuthus trogontherii* appeared not later than in Süssenborn (Von Koenigswald & Heinrich 1999) and is a common constituent of glacial faunas, until the level (OIS 10) below the "*antiquus* Schotter" at Steinheim (OIS 9). In the overlying "*primigenius*-Schotter" (OIS 8) *M. primigenius* appeared. This species survived in Europe till around the Pleistocene-Holocene transition.

The first record of *Elephas antiquus* in Germany and surrounding areas and in France is in the Middle Pleistocene of Mosbach 2 and Soleilhac (both OIS 15), while in Italy it is around 0.9 Ma (Bout 1964; Palombo 1995 Sardella *et al*. 1998; Von Koenigswald & Heinrich 1999).

2. THE SPANISH RECORD

The localities with *M. trogontherii, M. primigenius* and *E. antiquus*, as well as isolated finds, are indicated in Figure 1. Those localities and finds of which the approximate age could be estimated on the basis of geological, palaeontological or archaeological criteria have been indicated in Figure 2.

The first appearance of *Mammuthus meridionalis* in Spain is from Huelago carretera (Mazo 1989) from normally polarized sediments attributed to the Gauss epoch and an estimated age of some 2.7 Ma, and is slightly earlier at Montopoli, in sediments on top of the Gauss. The last record is in Atapuerca TD6 in sediments just below the Brunhes-Matuyama boundary (Van der Made in press) and is much older than the last record in Voigtstedt.

The oldest Spanish record of *M. trogontherii* is at Cúllar de Baza-1 (Mazo 1989). This locality has *Megaloceros savini*, and material assigned to *Bison* sp. (Azanza & Morales 1989). This bison possibly represents *Bison voigtstedtensis*, suggesting an age not later than that of

Süssenborn, otherwise the last locality with that bison, contrasting with a AAR date of 476+24 ka (Ortiz *et al.* 2000). Martín Penela (1988) described the fauna from Solana del Zamborino and attributed part of the proboscidean material to *Mammuthus trogontherii*. The rich fauna is interpreted to be correlative of Atapuerca TG10 and OIS9-10 (Van der Made, in press).

Most or all Spanish records of *M. primigenius* are of the Late Pleistocene. Though the species entered Europe two cycles earlier, there is no evidence of it having entered Spain at that time. The southernmost record of this species is at El Padul (Granada).

The earliest record of *Elephas antiquus* in Spain is in Huescar-1 (Mazo, 1989). The locality has *Stephanorhinus etruscus*, *Mimomys savini*, *Microtus brecciensis*, *Microtus gregaloides* and *Castillomys crusafonti* is placed below Atapuerca TD4-6 (Sesé *et al.* 2001), with a probable age between some 0.9 and 1 Ma. This contrasts with a datation based on amino acid racemisation of 491+84 ka (Ortiz *et al.* 2000). The latest records are Late Pleistocene in age and are at Cova Negra, Buelna and Olha (Mazo 1995, 1998; Altuna 1984).

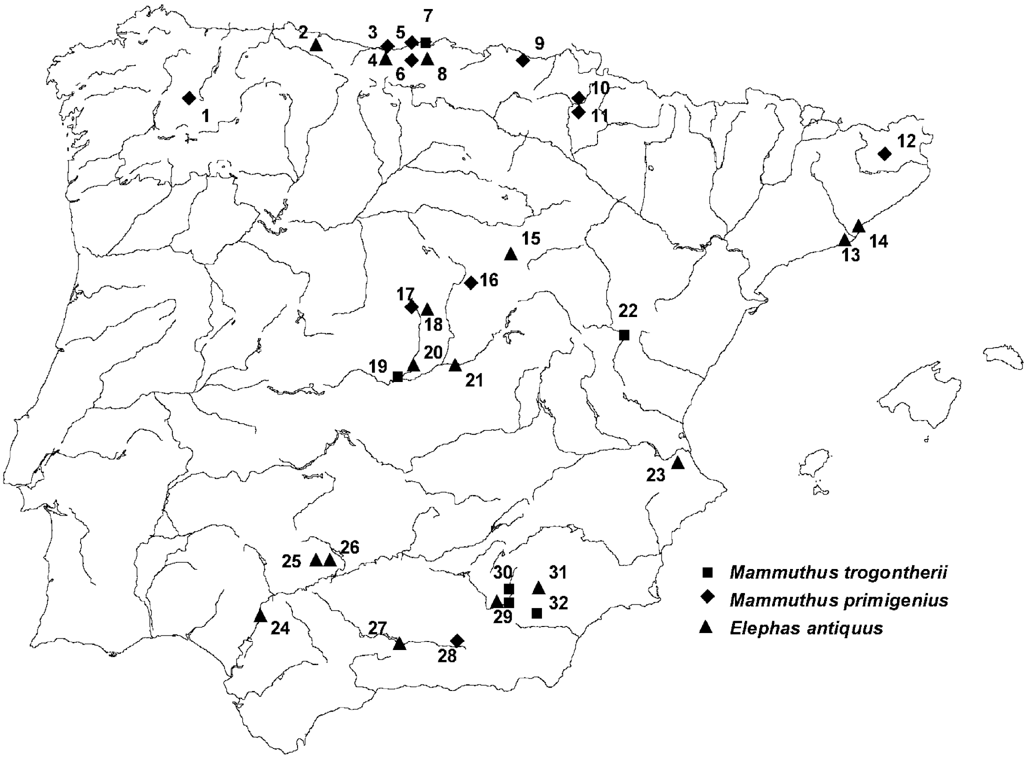

Fig.1 - Location map of sites with proboscidean remains. *Mammuthus trogontherii*: 7 = Peña Cabarga (Santander); 19 = Toledo (Toledo); 22 = Teruel (Teruel); 29 = Solana del Zamborino (Granada); 30 = Cúllar de Baza-1 (Granada); 32 = Daimuz (Granada). *Mammuthus primigenius*: 1 = Incio (Lugo); 3 = El Pindal & Cueto de la Mina (Asturias); 5 = Pámanes (Santander); 6 = Altamira & Cueva Morín (Santander); 9 = Itziar and Labeko Koba (País Vasco); 10 = Olha (País Vasco); 11 = Isturitz (Navarra); 12 = Olot (Gerona); 16 = Cueva de los Casares (Guadalajara); 17 = La Aldehuela (Madrid); 28 = El Padul (Granada). *Elephas antiquus*: 2 = Llanera (Asturias); 4 = Buelna (Asturias); 15 = Torralba & Ambrona (Soria); 18 = Madrid (Transfesa/Villaverde, San Isidro, Los Rosales, Arriaga, Orcasitas, Aridos, Ciempozuelos); 20 = Pinedo (Toledo); 21 = Aranjuez (Madrid); 23 = Cova Negra y Bolomor (Valencia); 24 = La Rinconada (Sevilla); 25 = Hornachuelos (Córdoba); 26 = Almodóvar del Río (Córdoba); 27 = Loja (Granada); 29 = Solana del Zamborino (Granada); 31 = Huescar-1 (Granada).

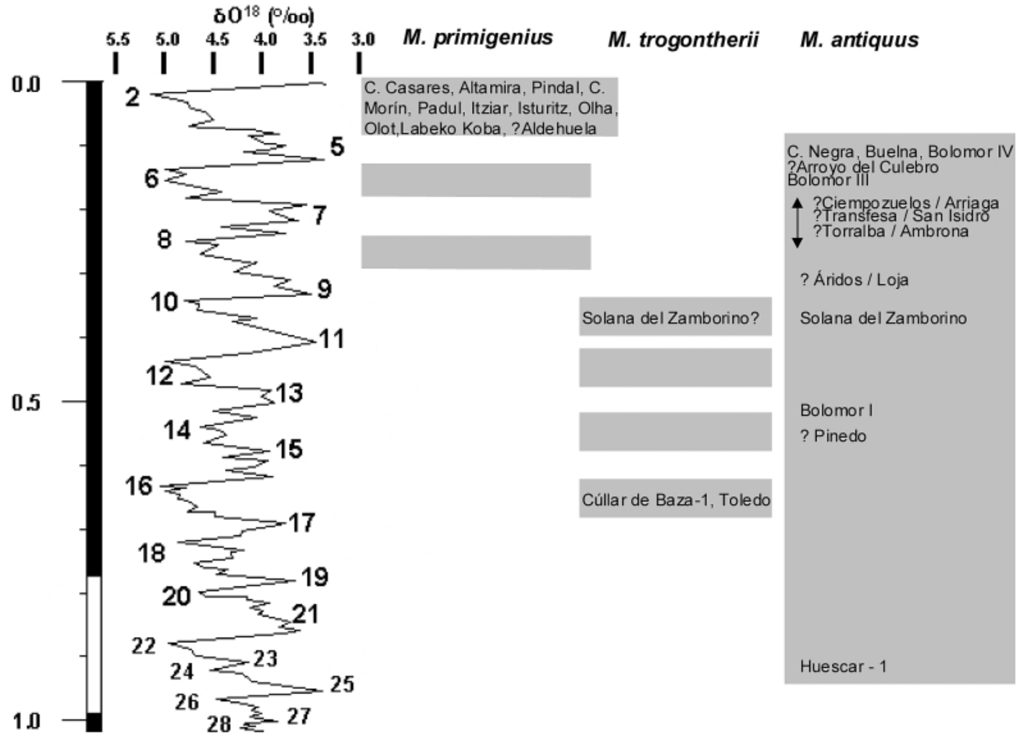

Fig.2 - Time and palaeomagnetic scales, δO^{18} values and stages (OIS) and approximate stratigraphic position of the Spanish locationes with proboscideans remains. The grey areas indicate the known or expected temporal distribution of the proboscideans. Arrows and question marks indicate insecure stratigraphical position. Question marks behind a locality name indicate dubious taxonomy.

3. DISCUSSION

The Spanish proboscidean record resembles that from the rest of Europe, save for relatively early appearances of *M. meridionalis*, and *E. antiquus*, and the late appearance of *M. primigenius*. At present we are not able to establish whether the records of *M. trogontherii* and *E. antiquus* are of glacial or interglacial chronology, though it is possible that the presence of the former is restricted to glacial periods and that of the latter continuous. The most interesting parallel with the rest of Europe, is the long period with a single proboscidean species, between some 2.7 and 1 Ma, followed by a period when two species were present.

The appearance of both *Elephas antiquus* and the replacement of *Mammuthus meridionalis* by *M. trogontherii* occurred after a long relatively stable period and in the middle of important faunal changes. These changes started around some 1.2 Ma with the dispersal of a number of taxa that later were to become adapted to, or at least more common in, glacial environments: *Bison, Praeovibos, Soergelia, Capra alba* as well as a cervid that was probably adapted to relatively open environments, *Eucladoceros giulii*. During the Jaramillo Event, *Capreolus*, *Bison menneri*, *Hemitragus bonali* and *Alces latifrons* dispersed into west and central Europe. During the latest Early Pleistocene, *Elephas antiquus*, *Sus scrofa*, *Cervus elaphus* and *Crocuta crocuta* dispersed into Europe. During the earliest Middle Pleistocene *Stephanorhinus hundsheimensis*, *Megaloceros savini*, *Ovibos suessenbornensis* and *Praeovibos priscus* dispersed into Europe.

At about the time that *Mimomys savini* was replaced by A*rvicola cantianus, M. meridionalis* was definitively replaced by *M. trogontherii.* Various later waves of dispersals into Europe are recorded. These appearances are not matched by an equal number of extinctions, and biodiversity increased on a European wide scale. Part of these animals developed into glacial, others into interglacial taxa. (Van der Made 1999, in press.)

The Milankovich cycles are detected in oxigen isotopes and dust concentrations in deep sea cores, as well as by the sedimentological study of out crops. Around 1,2 Ma the amplitude of the Oxigen Isotope variations increased and around 0,9 Ma, the dominant period passed from 40 ka to 100 ka, which is the cyclicity of the glacials (Shackleton 1996).

These climatical changes lead to an important change in biogeography; a cyclic pattern of biogeographical changes was established. This appearently is wat allowed for an increase in biodiversity in general, and in the proboscideans in particular. Due to the climatical changes, proboscidean diversity in Europe increased from one to two genera: *E. antiquus* filled the “interglacial” niche, while *Mammuthus* adapted progressively to the “glacial” niche.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

Aguirre, E. 1968-1969. Revisión sistemática de los Elephantidae por su morfología y morfometría dentaria. *Estudios Geológ*. 24: 109-167, 25: 123-177, 317-367.

Altuna, J. 1984. Primer hallazgo de Mamut (*Mammuthus primigenius* Blumenbach) en el País Vasco Meridional. *Munibe* 36: 27-32.

Azanza, B. & J. Morales 1989. Los artiodáctilos de Huélago-1 y Cúllar de Baza-1 (cuenca de Guadix-Baza, Granada). *Trab. Neogeno-Cuaternario* 11: 289-315.

Azzaroli, A. 1977. Evolutionary patterns of Villafranchian elephants in Central Italy. *Atti Acad. Naz. Lincei, Memorie, Classe Scienze fis., ser.* 8: 149-168.

Bout, P., 1964. Étude stratigraphique et paleogeográphique du gisement de mammifères fossiles Pléistocène moyen de Solilhac, près Le Puy-en-Velay (Haute-Loire) France. *Geol. Mijnbouw* 43: 83-93.

Koenigswald, W. von & Heinrich,W.D. 1999. Mittelpleistozäne Säugetierfaunen aus Mitteleuropa - der Versuch einer biostratigraphischen Zuordnung. *Kaupia* 9: 53-112.

Lister, A. 1996. Evolution and taxonomy of Eurasian mammoths. In J. Shoshani & P. Tassy (eds.) *The Proboscidea, evolution and palaeoecology of elephants and their relatives*: 203-213. Oxford Univ. Press.

Made, J. van der 1999. Ungulates from Atapuerca-TD6. *J. Hum. Evol.* 37: 389-413.

Made, J. van der, in press. Biostratigraphy of the Lower and Middle Pleistocene mammalian faunas from Spain. *Quaternaire*.

Martín Penela, A.J. 1988. Los grandes Mamíferos del yacimiento acheulense de la Solana del Zamborino, Fonelas (Granada, España). *Antropol. Paleoecol. Hum.* 5: 29-187.

Mazo, A.V. 1989. Nuevos restos de Proboscidea (Mammalia) en la cuenca de Guadix-Baza. *Trab. Neogeno-Cuatenario* 11: 225-237.

Mazo, A.V. 1995. Una mandíbula de *Elephas antiquus* (Proboscidea, Mammalia) en Ciempozuelos (Madrid). *Col. Paleontología* 47: 47-53.

Mazo, A.V. 1998. El elefante fósil de Buelna (Asturias). Nota preliminar. *Estudios Geol.* 54: 273-274.

Ortiz, J.E. *et al.* 2000. Datación de yacimientos paleontológicos de la cuenca de Guadix-Baza (sector de Cúllar-Baza, Granada, España) y primera estimación de la edad de la apertura de la cuenca mediante el método de racemizacián de aminoácidos. *Geogaceta* 28: 109-112.

Palombo, M.R. 1995. Gli elefanti del Pliocene superiore e del Pleistocene dell’Italia centrale peninsulare. *Studi Geol. Camerti*, vol. spec. B (1994): 447-457.

Sardella, R., Abbazzi, L., Argenti, P., Azzaroli, A., Caloi, L., Capasso Barbato, L., Di Stefano, G., Ficcarelli, G., Gliozzi, E., Kotsakis, T., Masini, F., Mazza, P., Mezzabotta, C., Palombo, M.R., Petronio, C., Rook, L., Sala, B. & Torre, D. 1998. Mammal faunal turnovers in Italy from the Middle Pliocene to the Holocene. *Medelingen Nederlands Inst. Toegepaste Geowetenschappen TNO* 60: 499-512.

Sesé, C., Alberdi, M.T., Mazo A., & Morales, J. 2001. Mamíferos del Mioceno, Plioceno y Pleistoceno de la Cuenca de Guadix-Baza (Granada, España): revisión de las asociaciones faunísticas más características. *Paleont. i Evol.* 32-33: 31-36.

Shackleton, N. 1996. New data on the evolution of Pliocene climatic variability. In E.S. Vrba, G.H. Denton, T.C. Partridge & L.H. Buckle. (eds.) *Palaeoclimate and evolution with emphasis on human evolution*: 242-248. New Haven and London: Yale University Press.

Computer-based recording systems of Pleistocene deposits with large mammals

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SUMMARY: The computerised recording of archaeological or paleontological sites, rich in proboscidean bones, present a particular challenge to excavation teams. The need of precise mapping of very large bones at a relatively fast pace, and of integrating provenience and visual data with faunal analysis and other archaeological or taphonomic data causes problems. In archaeological sites total stations are used for automatic recording of Cartesian coordinates for individual objects and for topographic mapping; they are not normally used for imaging purposes. At the Lower Palaeolithic sites of Ambrona and Torralba we have used a recording method which allows the integration of accurate images with speedy collection of provenience and other data. The total station is used to register the multiple points forming the outline of single proboscidean bones or other large bones, while small bone fragments and lithic artefacts are recorded with single coordinates in the traditional manner. In the field lab, graphic tablets and AutoCAD™ software are used to produce bone images at the desired scale and to plot them in distribution maps. The management of spatial, faunal and other analytical data is accomplished with a GIS program (ArcView™).

1. BACKGROUND

This article reviews the specific problems that originate at large open-air archaeological sites with faunal assemblages characterised by the presence of large mammal bones in clusters of variable densities. These features demand the synchronised excavation of several square meters, thus increasing the risk of errors, during the materials' spatial recording, which may result from cumulative small variations in the reference grid system. Other difficulties arise when trying to integrate assemblage data with their macro and micro-stratigraphic context, and, more generally, in the global management of archaeological data in the field.

For these reasons we consider inappropriate to use at these sites recording methods traditionally implemented in caves and rockshelter (Laplace & Meroc 1954). They are based on the physical division of work areas, treating each square meter as a single and unique record unit since cartesian coordinates have separate origins for each square. Thus individual items are provenienced in reference to a single square. Clearly the system is inconvenient when dealing with large objects spanning over more than a square meter.

In fact the volume of proboscidean fossil bones, and other large mammals, and their distribution over large areas requires that we use a recording system that treats the whole archaeological site as a single spatial unit. The use of a total station provides the accuracy we need during the data recording. The total station is used to register the spatial location of all the archaeological record (Parcerisas & Mora 1995), lithic and bone remains, but also to record all the stratigraphic sections, all topographic mapping data, the location of geological samples, and any other information relevant to the taphonomic and archaeological analysis of the site.

This results in an integrative understanding of the nature of the archaeological data. We can easily see the relationships between the simple facts of the archaeological observation (the real entity that is been observed: lithic remains, bones, etc) and their attributes (i.e., the properties that have been deduced upon their study, such as stratigraphic position, typological classification, etc.). The attributes result from the analytic method used for their study, and can be modified during the course of further research. Therefore the data should be under a management system that recognizes their diversity and would allow change. It should also be able to adjust to the specific properties of the project and allow the simultaneous analysis of different attributes and of the spatial position of the remains to which these attributes refer.

In order to create this network of relationships between attributes and spatial provenience, it is necessary to digitize the contextual information available especially for large bones. Because of their size they may display complex features: simultaneous position in more that one stratigraphic unit, different degrees of alteration and abrasion, discrete topographic phenomena, etc.

In sum, the recording method should perform, in a synchronised manner, three tasks: 1) verification of the archaeological data by means of cross analysis; 2) detailed maps of items, and 3) the creation of a data base that could be used to create models and to test working hypotheses.

2. The Recording System

Between 1993 and 1999 we have developed a data recording system applied, among other archaeological sites, to the Middle Pleistocene sites of Ambrona and Torralba (Spain).

The procedure consists of four stages: 1) data acquisition and recording on a magnetic support, 2) data transfer to a personal computer and exporting to a database program, 3) spatial information digitalisation, and finally, 4) integration of all the data and the creation of specific maps.

2.1 Data acquisition and recording

All the spatial data are obtained with the aid of the total station, or electronic teodolite with an optical distance measurement device. Its use, more and more frequent in archaeological projects, allows the storage over a magnetic support (hard disk, PCMCIA card, etc.) the measurements and Cartesian coordinates (x, y and z) of each selected point.

In one single work session, with only the need of selecting identifying *strings*, we can record diverse data from independent locations within the excavation area. In relation to the number of points need to be taken and the time investment required for the task, the first thing to do during the data acquisition phase is topographic mapping. The mapped surfaces may correspond to the preliminary stage of the excavation areas, or the area left at the time fieldwork concludes – in this case we are documenting and checking the excavation process. They can also correspond to paleo-surfaces, or stratigraphic interfaces. This kind of data, together with the recording of stratigraphic sections, provide useful information on the geometry of layers and can help us understand the site formation processes and their effects on the archaeological materials.

However, it is during the recovery of the archaeological items that a wide variety of recording procedures is needed. The size of the object to be registered, and whether this item will be promptly removed during the fieldwork or left in situ for future museum purposes, will determine the procedure.

For all the small items or those that do not need a real drawing, we take a single point (less commonly we take two points as the upper and lower coordinate of the object) and we assign to it a number and name of the layer. Numbers are, of course, unique and given sequentially to all the objects that belong to the same archaeological level, independently from its provenience within the site.

For those remains that due to their size or other circumstances required realistic drawings (mainly large bones), these can be done in two different ways, depending on the urgency for the conclusion of the task. The more elaborate procedure includes the realistic sketch of the bone using a scale that allows for some details while making the task relatively easy. Bones are drawn individually on separate sheets; there is no need of positioning objects in relation to others nearby (as in traditional archaeologcal mapping by hand) because accurate plans will be reconstructed later by the drawing software.

Once the sketch is finished we record the spatial position of several points of the bone and mark them on the drawing for clear identification. Points should be placed on distinctive morphological features of the bone.

In the lab, and after stage two of the recording system, we get a map of points that are lined out together with the aid of the bone sketch. The day after, when we return to the field, we can verify the accuracy and reliability of the resulting drawing, and if necessary make the required changes to improve it. This recording process, needs one or two days to be completed but it guarantees a high quality and precision of the final drawing without the need of having an experienced artist at the site. From the drawing we can obtain detailed information on the bone morphology and dimensions, orientation, length and width of fractures, distance between fragments and other features deemed relevant. This information allows us to relate these or other features with the morphology of the substrate or other archaeological remains that may have not been detectable during the excavation process.

The abbreviated version of this procedure requires a more precise sketch, because this will be the final drawing to be digitized. Each one of these sketches should be done on separate sheets of millimeter paper. It is advisable to draw the bone aligning its longer axis to the paper squares, to check measurements and proportions more easily. For relatively small bones natural size may be the more appropriate scale to be used.

Once the sketch in finished, we take only two co-ordinates, placed at clearly identifiable points distant from each other, preferably the two more distant points on the bone longer axis.

These two coordinates will be used to calibrate the graphic tablet, verify the bone real dimensions and its position and orientation.

This second procedure is faster than the previous one, but the main disadvantage is that the final result will depend on the ability of the draftman. However, we think that with a minimum of effort and supervision from the archaeologist in charge, similar quality levels can be achieved.

2.2 Data transfer and organisation

All the data recorded during a day of fieldwork are saved in ASCII format and stored in daily independent files. This allows future file revisions, as needed. These files are then processed with a database application (IO) that undertakes the tasks of distributing the information contained in each daily file into four general database files. For our convenience we name these general files Ua, To, Ge and Fo.

The *Ua* file contains all the information related to the archaeological items: stratigraphic unit, coordinates and a preliminary material and morphological classification of the remains. This file provides an inventory of the materials recovered on daily bases.

This file can be related to other database files in a hierarchic structure, going from a more general to a theme specific information files. The other files contain data on taxonomic and taphonomic attributes of bones, technological and raw material determinations for stone artifacts, photographic information, etc.

The *To* file includes all the data obtained from topographic mapping of the excavation surface at the beginning or end of the fieldwork, as well as stratigraphic sections. Two-and three-dimensional topographic mapping of paleo-surfaces, and other surfaces can be obtained from these files. We can put on these maps the archaeological items contained in the Ua file, and their drawings.

The *Ge* file contains the spatial location of all the pollen and sediment samples.

Finally, the *Fo* files contain the reference points used in all the drawings, whether these are bones, structures or other remains. The drawing files contain several points for each object, allowing two-dimensional, and eventually three-dimensional, representations. They also provide information on the object orientation and depth. see above. The 2 original points of each bone are related with a particular file for every bone . In fact you have 2 kinds of data base: first the general data base of the archaeological site in wich every item are identified by two 3D coordinates, and a second kind of data base: each particular bone with a variable number of 3D coordinates are an independent data base.

2.3 Digitalization of spatially-referenced drawings

In the lab, all the drawn archaeological remains are vectored using a graphic tablet with draw assistant software; we use AutoCAD™. Each drawing is independently digitized in the graphic tablet using the coordinates stored in the Fo file, providing the object position, dimension and orientation.

For a more effective use of the resulting AutoCAD™ file, each bone is stored in an independent “layer”. The reference label is a code combining information regarding the object stratigraphic unit, its number and distinctive features.

This reference label is added to the Ua and Fo files. Therefore, all the independent database files can be related to the spatial entity represented by the drawings.

Digitalization of all the archaeological remains is quite laborious. However, this time-consuming task provides visual representation that can be related to any of the attributes contained in other files.

2.4 Data management and mapping

A standard geographic information system (GIS), Arcview™, is used for data management purposes. It is a simple and easy to use software program, that can be installed in almost any computer. At this point, all the information is organized in files and management is almost automatic. The existing literature on the topic explains extensively the use and features of GIS programs (Lock & Stancic 1995).

3. Final remarks

The automated system we have described is based on the recording of coordinates for all archaeological items (bones and stone artifacts), geological and other data that may contribute to an understanding of the site formation and nature.

Large proboscidean remains requires the use of a total station to produce drawings that are closer to reality as possible. At the same time, this recording system creates data files that can be related using the object spatial references and can be managed using any GIS program.

The system requires hardware and software that is readily available in the market, and only requires the development of specific software routines to speed up some of the more tedious data management processes.

Compared to other existing archaeological data recording systems, as terrestrial photogrammetry, our proposal turns out to be cheaper, easier to use and more accurate.

4. References

Lock, G. & Stancic, Z. (eds) 1995. *Archaeology and Geographical Information Systems, an european perspective*. London: Taylor & Francis Ltd.

Laplace, G. & Méroc, L. 1954. Application des coordonées cartésiennes à la fouille d’un gisement. *Bulletin de la Société Préhistorique Française* 51: 56-66.

Parcerisas, J. & Mora, R. 1995. La Estación Total Inteligente y sus aplicaciones en el trabajo arqueológico. In L. Valdés *et al.* (eds.), *Aplicaciones informáticas en arqueología: Teorías y sistemas*. Bilbao: Gastiburu.

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Middle Pleistocene fauna and lithic implements from Pagliare di Sassa (L'Aquila, Central Italy)

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SUMMARY: Faunal remains consisting of disarticulated skeletal elements showing little or no evidence of transport were found in a sandy alluvial fan outcrop at Pagliare di Sassa (L'Aquila, Central Italy). The fauna (Aves, an undetermined carnivore - possibly *Crocuta* - whose presence is attested to by a coprolite, ? *Elephas (Palaeoloxodon) antiquus, Stephanorhinus hundsheimensis, Hippopotamus* ex gr. *H. antiquus, Megaloceros savini, Megaceroides verticornis, Dama* sp (?*Dama clactoniana*), *Lepus* sp. and an Arvicolid rodent) imply a middle Galerian date. Two lithic implements, and a bone fragment, broken when fresh, with a complex fracture pattern and impact scars, provide evidence for a limited human presence on this site.

1. INTRODUCTION

In 1977 fragmented fossil remains of a large elephant were discovered in a sand quarry at Pagliare di Sassa (L'Aquila, Central Italy). Preliminary excavation tests carried out in 1998-1999 by the Soprintenza Archeologica dell'Abruzzo, with the collaboration of the Università degli Studi de L'Aquila and of the Museo di Paleontologia (Università degli Studi di Roma "La Sapienza"), led to the discovery of slightly fossiliferous horizons which are, nevertheless, of considerable taxonomic and taphonomic interest (Agostini *et al.* 1999).

More recently, systematic excavation has unearthed a large number of vertebrate fossil remains, enabling a better chronological placing for this small fauna.

2. THE GEOLOGICAL SETTING

The fossil-bearing sequence takes the shape of an alluvial fan deposit composed of grey basal clays partially pedogenised at the top where they were cut into by a channel. The latter is filled with a sequence of sandy lenses with fine gravel intercalations that at times fit into each other and pass laterally to form regular plane-parallel beds. The fossil remains were discovered in two "horizons". The first is located at the clay/sand transition. The bones here have undergone limited transport by a low

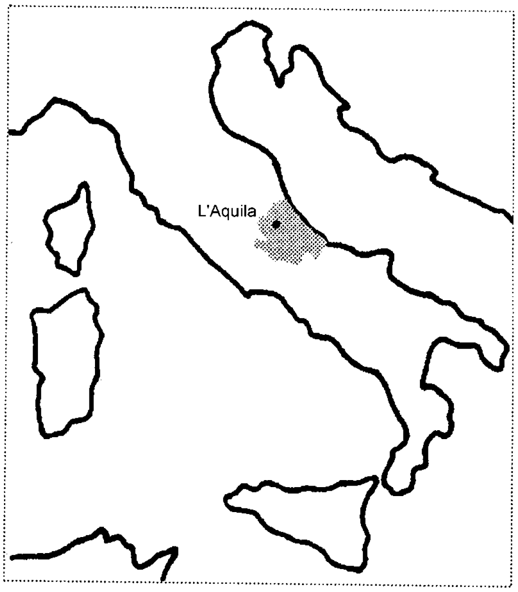

Fig.1 - Localisation of the site.

energy agent. There is evidence of localised reworking and re-deposition: the unsealed distal epiphysis of a juvenile rhino metapodium, for instance, was presumably detached and caught up in a whirlpool before being redeposited in a sand bed overlaying that containing the diaphysis. The second horizon contained a smaller number of bones; the latter were recovered from the lenses and beds marking the transition to the upper parts of the lenses. From a purely morphostratigraphic viewpoint, the alluvial fan which is now cut by two streams distinct from the watercourse which had originally created it, is suspended over the alluvial plain of the river Laio, a right tributary of the river Aterno. It can be placed in the middle to lower part of the Middle Pleistocene. Paleomagnetic surveys have consistently registered normal magnetic polarity in the basal clays (Speranza, unpublished data).

3. FAUNA

The faunal remains from the first horizon consist of disarticulated skeletal elements showing limited or no evidence of transport. The best represented taxon from this horizon is a juvenile rhino, followed by an abundance of remains of a large elephant, as well as a hippo and two cervids, though the latter two taxa are scantily documented. Specimens from the second horizon are even less abundant and show a more varied degree of preservation, ranging from abraded splinters to unaltered complete elements. There are at least two Aves, an undetermined carnivore, possibly *Crocuta*, whose presence is attested to by a coprolite, ? *Elephas (Palaeoloxodon) antiquus*, *Stephanorhinus hundsheimensis*, *Hippopotamus* ex gr. *H. antiquus*, *Megaloceros savini*, *Megaceroides verticornis*, *Dama* sp (?*Dama clactoniana*), *Lepus* sp. and an Arvicolid rodent. The best represented are the large cervids and the rhinoceros.

The elephants are documented by only very fragmentary remains (occipital condyles, a few tusk fragments, ribs and vertebral apophyses, a few parts of a scapula, a humerus and an ulna) probably belonging to a single, large individual. None of the specimens are diagnostic from a taxonomical viewpoint. Only the tusk fragments offer some clue in the absence of helicoidally arranged striae, which are instead typical of the mammuthine lineage. The pattern of the Schreger lines cannot be detected with any certainty because of the diagenetic process. Nevertheless, the outer angles are more similar

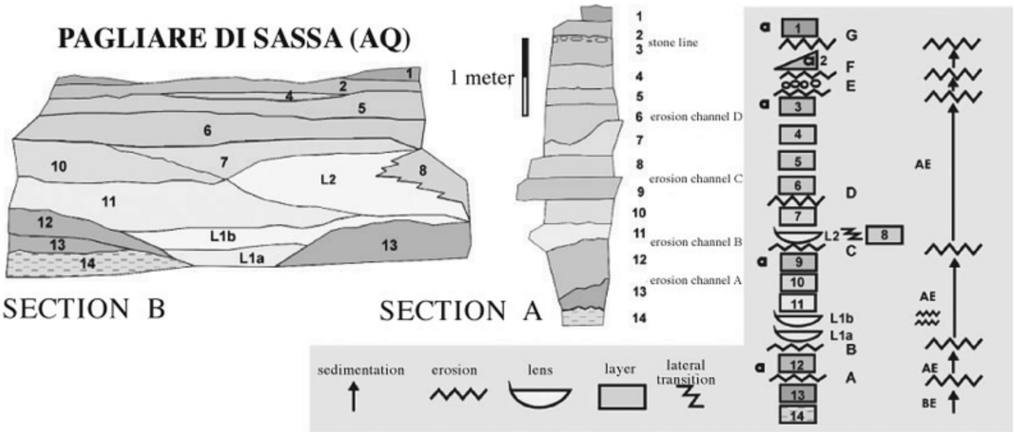

Fig.2 - Stratigraphic diagram.

to the modal values of *E. antiquus* than those of the *Mammuthus representatives*.

The rhino remains are not only more abundant, but also fairly indicative taxonomically, though belonging to a juvenile specimen. The overall morphological characters and the morphometry of the dentition, as well as of the stylopodial and autopodial bones are suggestive of *Stephanorhinus hundsheimensis* (Fortelius *et al.* 1993).

The hippo remains include both a fairly large adult, comparable to the Late Villafranchian *H. antiquus* representatives from the Upper Valdarno basin, and a very juvenile individual, documented by a slightly worn, isolated D_4 and a tibia. Despite its large size, the adult hippo sample includes an almost complete and quite slender calcaneum. Given the ample morphological and dimensional range of these animals, the lack of truly diagnostic elements denies any sounder specific determination.

At least three cervid species are documented, i.e. *Megaceroides verticornis*, *Megaloceros savini* and *Dama* sp.

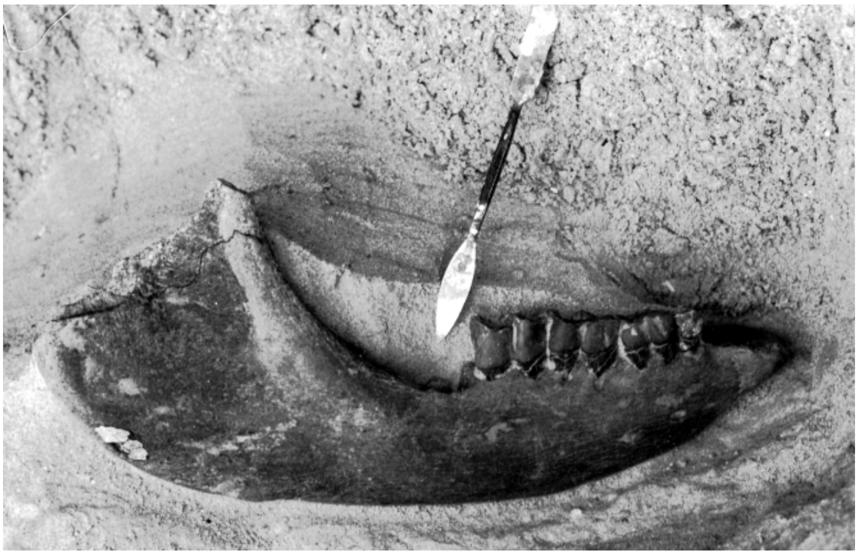

Fig.3 - *Stephanorhinus hundsheimensis*, left emimandible.

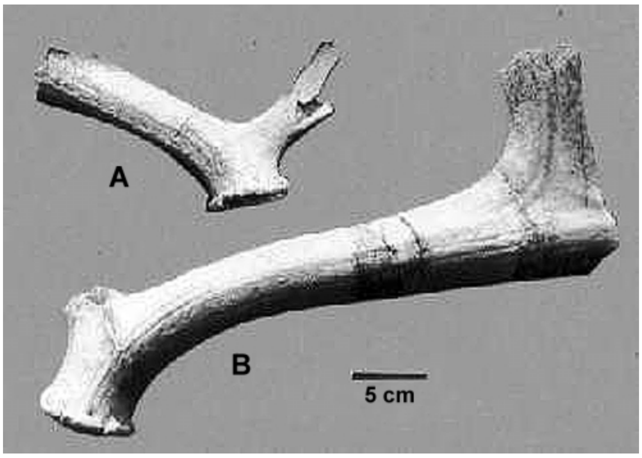

Fig.4 - A) *Megaloceros savini* left shed antler; B) *Megaceroides verticornis* right shed antler.

M. verticornis is represented by two antler fragments and an incomplete mandible. The morphological traits of the antler fragments, in particular the evidence of branching in the terminal part of the beam, permit this megacerine's attribution to the subspecies *M. verticornis dendroceros* Ambrosetti, 1967.

M. savini is also documented by two proximal fragments of shed antlers. This species is easily identified because of the peculiar morphology of the basal portion of the antler in which the markedly flattened first tine is inserted very close to the burr.

Amongst the postcranial skeletal remains, two metatarsal bones are worthy of more detailed description and some discussion. In fact, the two specimens are longer and more slender than those usually characteristic of *M. verticornis*. These remains cannot even be ascribed to *M. savini*, as the literature only reports the description of antlers and incomplete skulls, as well as of very fragmentary remains of the postcranial skeleton.

The presence of a large cervid with very slender limbs has recently been reported in several late Early Pleistocene to early Mid-Pleistocene sites in Europe. Kahlke (1997) ascribed many of the remains from Untermasfeld (late Early Pleistocene, Jaramillo subchron) to the new species *Eucladoceros giulii*. Specimens from Atapuerca (level TD6, early Middle Pleistocene), Venta Micena (latest Early Pleistocene) and Akhalkalaki (Kahlke 1997; Made van der 1999) have also been referred to the same taxon.

After preliminary analysis, the metatarsals from Sassa show length and morphological indexes (i.e. robustness index) totally comparable to those of *E. giulii*. Nonetheless, reference to the genus *Eucladoceros* of the remains from the European localities mentioned above should be supported by a more detailed comparative analysis. It cannot be ruled out that these remains, as well as the metatarsals from Sassa, actually belong to one of the "giant deer" species (*Megaceroides* o *Megaloceros)* which were already present at the late Early Pleistocene-early Middle Pleistocene.

The cervid remains from Sassa also include palmated antler fragments and a fragment of P_2 which document the presence of a medium sized deer. The palmated antler fragments rule out the possibility that the cervid belongs to one of the Early Pleistocene *Dama*-like species known as *Pseudodama*, and are rather suggestive of *Dama*.

4. LITHIC IMPLEMENTS

Limited but sound evidence of a human presence was also discovered. Two slightly damaged flint flakes were retrieved from two different horizons. They had probably been carried over a short distance by natural agents as the edges are fractured but still fairly fresh and only slightly abraded. The two implements are not diagnostic, except for the characteristically ringed bulbar surface of the larger one, which has the characteristics of a two-platformed flaking technique (see Cancellieri *et al.* 2001). A bone fragment, broken when fresh, also displays a complex pattern of fracture and impact scars suggestive of human intervention.

5. FINAL REMARKS

The deer assemblage from Sassa is altogether indicative of a fairly broad time spell which spans the lower and middle part of the Middle Pleistocene (Galerian Mammal Age sensu Gliozzi *et al.* 1997). However, as yetthe Pagliare di Sassa fauna lacks the elements that would allow for its precise biochronological positioning within the early Middle Galerian faunal units of Italy. However, the co-occurrence of *Megaloceros savini* and *Megaceroides verticornis* in Italy has only been reported in the Ponte Galeria local fauna (Ponte Galeria FU, *sensu* Petronio & Sardella 1999) at c. 750 ka bp (Milli 1998), whereas *Dama clactoniana*, of the more recent Isernia FU (c.600 ka bp, Coltorti *et al.* 2000) is not recorded at Sassa.

From a paleocological perspective it is worth noting that the presence of hippo in an inland and relatively highland area is indicative of a fairly warm climatic phase. The presence of woodland or open woodland browsers such as megacerini together with mixed feeders such as the rhino, or even grazers like the hippo - all open landscape dwellers - suggests a mixed environment with open grasslands and sparse arboreal cover characterised by the presence of streams and bodies of water.

The human presence at Pagliare di Sassa is consistent with the so-called “revised short chronology” for the earliest peopling of Europe (Roebroeks & Van Kolfschoten 1996). According to Roebroeks and Van Kolfschoten’s interpretation of the archaeological record, the southern fringes of the continent, including Italy, would have first been intermittently colonized as early as 1Ma, even if continuous settlement was to initiate only around 600ka.

6. ACKNOWLEDGEMENTS

The authors are particularly indebted to Prof. Massoli-Novelli, whose active commitment enabled them to carry out the excavation. They also wish to thank Dr. Speranza for the paleomagnetic analyses, Dr. Giardini for the palynological investigation, and the students and assistants from the Dipartimento di Scienze della Terra of the Università degli Studi di Roma “La Sapienza” and from the Università degli Studi de L’Aquila for their help during the excavations.

7. REFERENCES

Abbazzi, L. 1995. *Megaceroides obscurus* from val di Chiana (Cava Liberatori, Tuscany, Central Italy, Farneta f.u., early Pleistocene). Remarks on early evolution and systematics of *Megaceroides. Boll. Soc. Paleont. It.* 43 (2): 223-234.

Abbazzi, L. & Masini, F. 1997. *Megaceroides solilhacus* and other deer from the middle Pleistocene site of Isernia La Pineta (Molise, Italy). *Boll. Soc. Geol. It.* 35 (1996): 213-227.

Agostini, S., Manni, R., Massoli, R., Palombo, M.R. 1999. Il giacimento a vertebrati delle Pagliare di Sassa (l’Aquila). *Geoitalia* 2: 23-25.

Cancellieri, E., Coppola, A., D’Angelo, E., Di Leo, R., Rinaldi, M.F., Rossi, D. 2001. La tecnica di scheggiatura bipolare applicata ai ciottoli: considerazioni su un lavoro di scheggiatura sperimentale. *This volume.*

Coltorti, M., Ton-That, T., Marzoli, A., Arzarello, M., Buoso, N., Corrado, S., Di Bucci, D., Minelli, A., Naso, G., Peretto, C., Thun Hohenstein, U., Villa, I., 2000. New Chronostratigraphic and Paleoclimatic Data from the “Isernia La Pineta” site, Molise, Italy. In *SubCommission on European Quaternary Stratigraphy (SEQS), 2000 Meeting The Plio-Pleistocene Boundary and the Lower/Middle Pleistocene transition: Type Areas and Sections. Abstracts.*

Fortelius, M., Mazza, P. & Sala, B. 1993. *Stephanorhinus*(Mammalia: Rhinocerotidae) of western European Pleistocene, with a revision of S. etruscus (Falconer, 1868). *Palaeont. Ital.* 80: 63-155.

Gliozzi, E., Abbazzi, L., Ambrosetti, P., 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, Ostracods from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art. *Riv. It. Paleont. Stratigr.* 103: 369-388.

Kahlke, H.D. 1997. Die Cerviden-Reste aus dem Unterpleistozän von Untermassfeld. In R.D. Lahlke (ed.), Das Pleistozän von Untermassfeld bei Meiningen (Thüringen). *Bereich Quatärpaläontologie Weimar* 40: 181-275.

Made, J. van der 1999. Ungulates from Atapuerca TD6. *Journal of Human Evolution* 37: 389-413.

Mazza, P. 1991. Interrelations between Pleistocene hippopotami of Europe and Africa. *Boll.Soc.Paleont.It.* 30: 153-186.

Palombo, M.R., Villa, P. 2000. *Schreger lines as support in the Elephantinae*. Congress "The Holoartic Ungulates of the Pliocene and Pleistocene", 19-22 september 2000, Avignon.

Petronio, C. & Sardella, R. 1999. Biochronology of he Pleistocene mammal fauna from Ponte Galeria (Rome) and remarks on the Middle Galerian faunas. *Rivista Italiana di Paleontologia e Stratigrafia* 105: 155-164.

Roebroeks, W. & Kolfshoten Van, T. 1996. The earliest colonization of Europe: the short chronology revisited. *Antiquity* 70: 535-542.

The World of Elephants - International Congress, Rome 2001

The Elephant Butchery Area at the Middle Pleistocene site of Notarchirico (Venosa, Basilicata, Italy)

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SUMMARY: An Acheulean paleosurface was excavated in 1990 and 1991 at the Middle Pleistocene site of Notarchirico (Venosa, Basilicata). The area shows a great concentration of faunal remains together with a skull of *Elephas antiquus* with both tusks still *in situ* and with the mandible lying some meters away from its original anatomical position. Several lithic tools (hand axes, choppers, utilized pebbles and a few flakes tools) are directly associated with the paleontological remains. Various taphonomical considerations suggest the possibility that the area represents a butchery site where parts of this skull were scavenged by hominids.

1. INTRODUCTION

Recent geological studies indicate that the filling of the Venosa basin consists of three lithostratigraphic units. The basal one, known as the "Formation of Fonte del Comune", can be attributed to the end of the Lower Pleistocene and is contemporary with the early phases of the volcanic activity of Monte Vulture. This unit is covered by two volcanic-sedimentary units, the "Formation of Piano Regio" and the later "Formation of Tufarelle". Both of these occur within the major phases of volcanic activity and belong to early Middle Pleistocene, with a minimum absolute age of about 500 ka.

Absolute dating of different volcanic units of Monte Vulture suggest a short chronological span between about 740 and 600 ka for the two major phases of filling. In the Notarchirico sequence, the tephra emissions are mostly reworked, with the important exception of a level of alkalin vitric tuff which remains in primary position, the so-called "Tephra of Notarchirico", deposited in an environment of stagnant water. On the basis of Thermoluminescence and ESR dates, the "Tephra of Notarchirico" occurring directly above the Acheulean level F, can be dated to 640 ± 40 ka. At present this "Tephra of Notarchirico" represents the only direct fall-out positively identified in an Acheulean site in Southern Italy (Lefèvre *et al.* 1998; Piperno 1999). Tephrostratigraphic correlations agree with the conclusions of the detailed paleontological study and with micromammals identifications (Cassoli *et al.* 1999; Sala 1999).

The extensive archaeological evidence from Notarchirico shows a continuous alternating superimposition of levels with hand axes (from bottom to top, Levels F, D, A, A1, B) or without this tool (E1, E, C, Alpha), starting with the most ancient one (Level F) with hand axes, just below the alkaline vitreous tuff dated 640 ka.

Despite the fact that several hypothesis have been put forward (Leakey 1971; Chavaillon *et al.* 1979) to explain the alternation of techno-complexes differently characterized at a typological level in long lasting stratigraphic series such as Olduvai and Melka Kunture, we must admit that it is difficult to understand the different strategies characterized by the lithic assemblages of various sites of the African Lower Pleistocene and of the European Middle

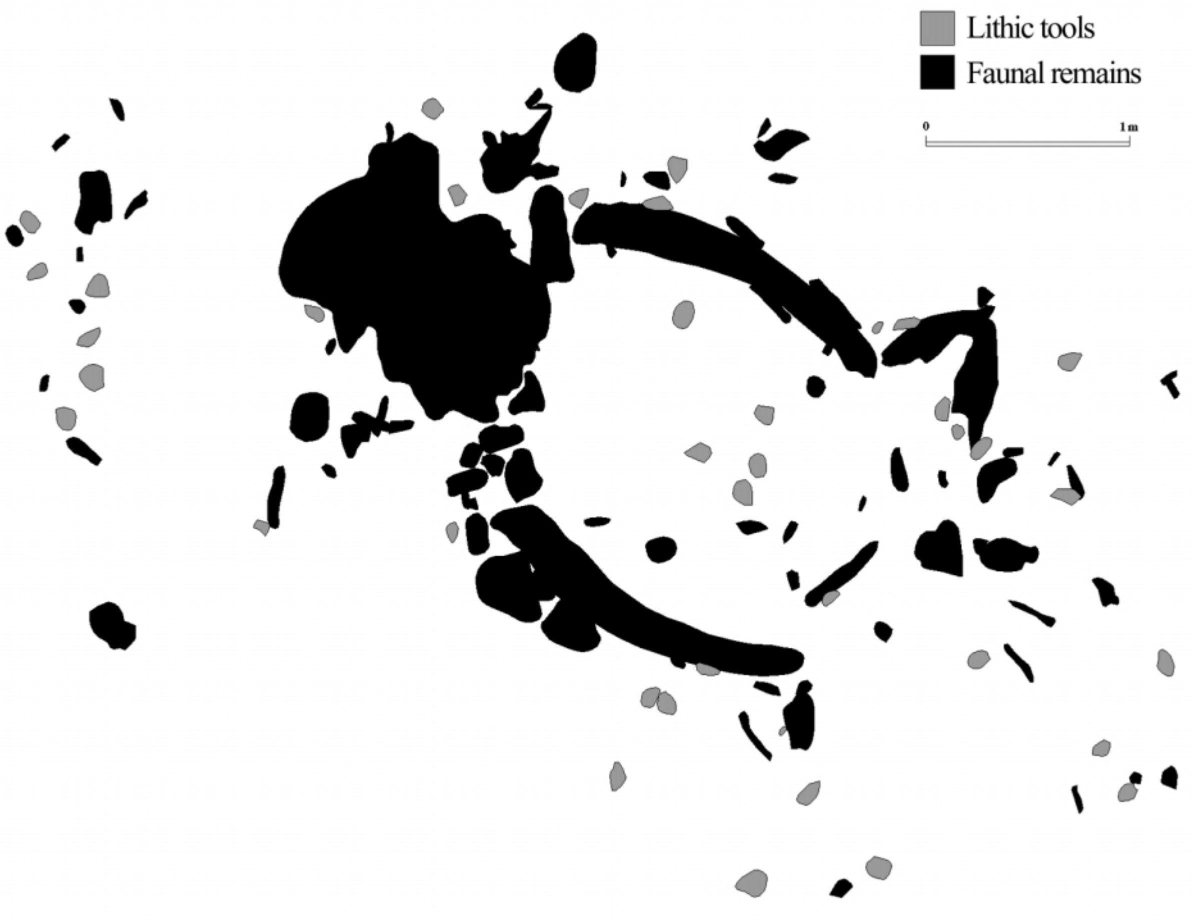

Fig.1 - Notarchirico. Level A1: Plan of the paleontological remains and lithic tools in the area of the elephant.

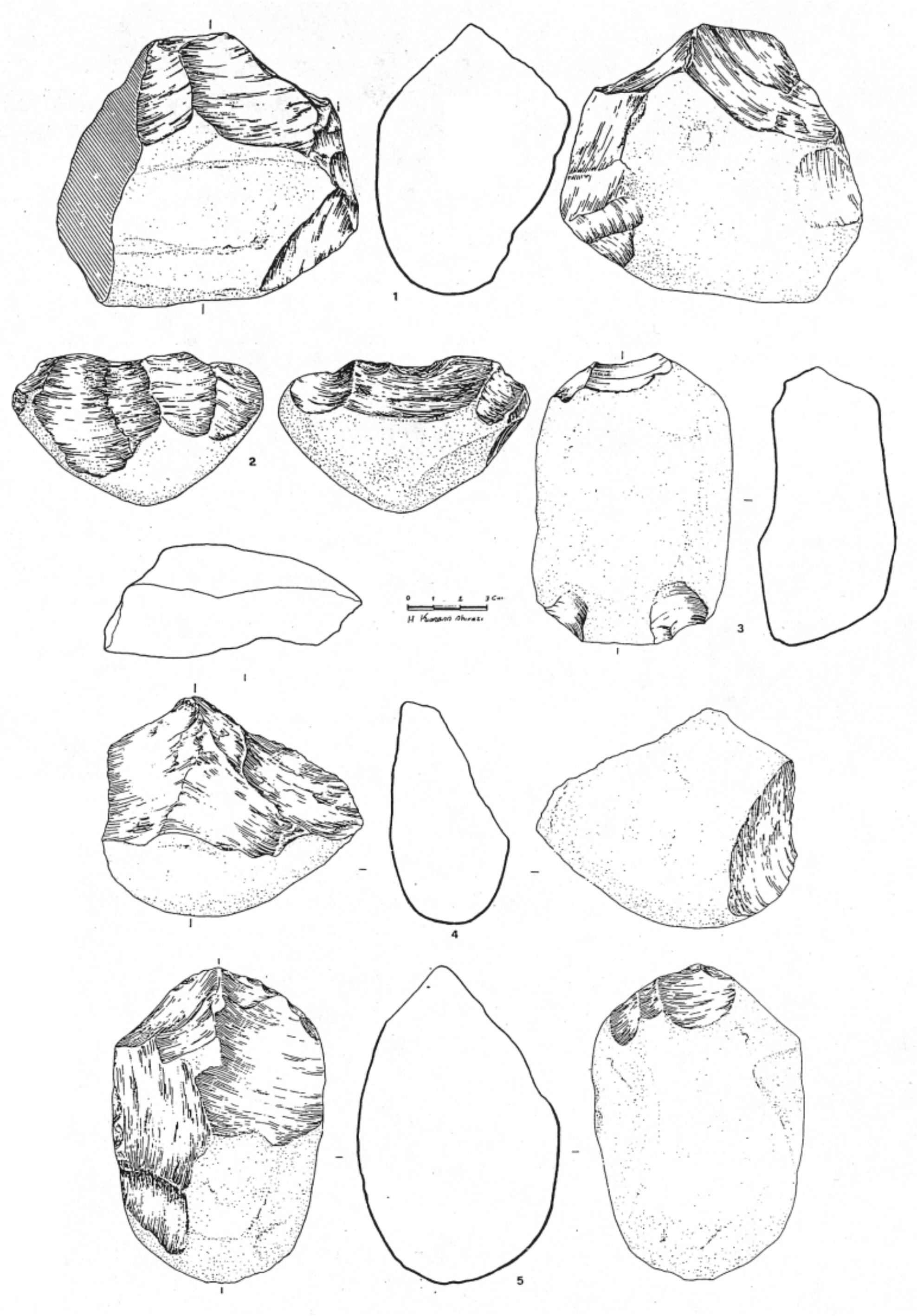

Fig.2a - Lithic Industry of the Elephant area.

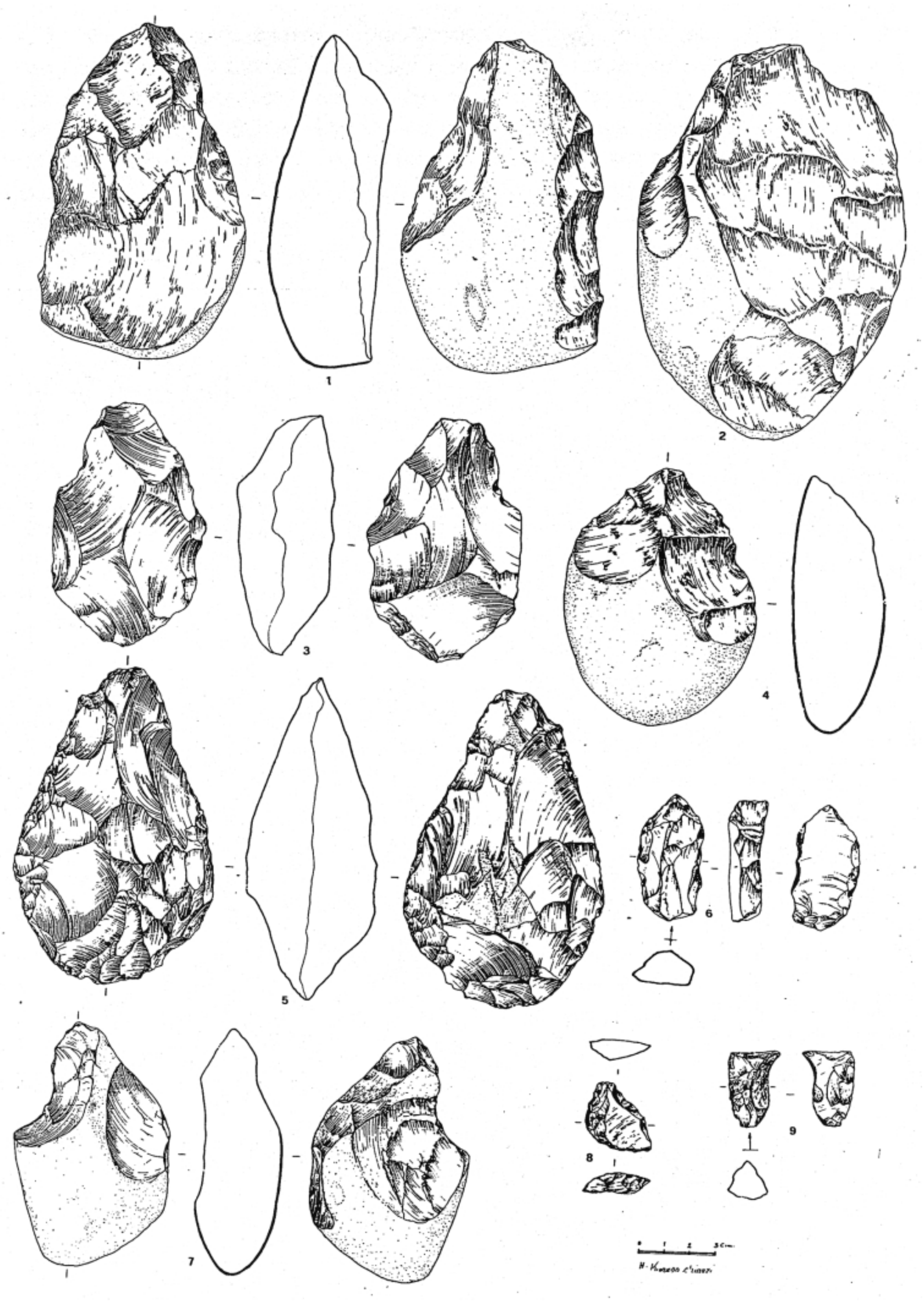

Fig.2b - Lithic Industry of the Elephant area.

Pleistocene. It seems equally impossible, in the majority of cases, to ascertain well beyond the residual evidence which can be observed in most lithic complexes, if such dichotomy actually corresponds to a substantial diversification of the Lower Paleolithic industries which would allow them to be placed in two or more parallel phyla corresponding to "Acheulean" and "not-Acheulean" separate traditions.

2. The Area of the Elephant

The surface with the remains of an *Elephas antiquus* covers an area of 6 x 4 m; most of the lithic and faunal remains rests within this area, while some of them are lying either at its bottom or at the top of level B, and others are clearly embedded in level B. 42 lithic and 85 faunal remains have been found in the area of the Elephant. 38 bone remains have been attributed to *Elephas antiquus* according to their size.

14 seem to represent anatomically unidentifiable fragments of elephant bones, 19 belong to Cervids and 14 are undetermined.

The great part of the remains belongs essentially to a skull of one sub-adult male individual, lying in an overturned position and lacking the entire masticatory apparatus and occipital (Fig. 1).

A portion of the left side of the cranial vault is still well preserved and shows the orbital area and part of the parietal; on its anterior part lies the alveolus of the tusks with still close-fitting some fragments of their radicular portions. Two upper posterior molars, showing moderate wear, were found respectively on the right and on the left of the skull, few cm away from their no more preserved original position. A highly worn anterior right molar, still preserving residuals of the last seven lamellas, was lying in front of the skull, while the left anterior molar was not found.

The left tusk was preserved in its middle-proximal part to a length of about 150 cm and was broken in its radicular part. The displacement of both tusks with respect to their original anatomical position was caused by the sinking of the bony portion of the incisor bones. Once the tusks were no more kept in their alveolus, they collapsed on ground, where they stay on their lateral surface. Numerous fragments of the area of the praemaxillare have been dislocated between the proximal extremity of the left tusk and the skull.

An apical portion of a tusk, measuring about 45 cm, was lying at a distance of a few cm from the distal fracture of the right tusk, resting in a slightly angular position with respect to its anatomical position. This fragment is actually lacking the great part of its external surface and has a maximum diameter of 7,5 cm, smaller than the one in association with the distal fracture of the tusk, measuring 23 cm. In spite of this discrepancy, its attribution to the same tusk is highly probable, even presuming a possible lack of an intermediate portion of the tusk.

The middle-proximal portion of the right tusk is present, with a length of about 140 cm. Its surface is badly preserved, because of the lost of the external ivory lamellas (max diameter: 21 cm; diameter at the fracture:14 cm). Several fragments have been displaced, but they either still maintain a contact with the tusk, or lie a few cm far from it.

The mandible is lying in connection with the fragmentary extremity of the right tusk; it is overturned and it lacks of both vertical ascending rami. In the lower part of its corpus, two large lacunae, uncovering the alveoli of the posterior molars, are visible. The left molar is still partially preserved, while the roots and the labial surfaces of both anterior molars are partially visible. A fragment of the vertical branch of the right hemi-mandible, still keeping the articular condyle, lies at a distance of about 20 cm from the mandible, with its external surface turned upside.

In the "area of the elephant" there is a clear correlation between the faunal remains and at least part of the 41 lithic tools found.

Lithic tools are quite uniformly distributed around the bone remains of larger size and inside the area between the two tusks.

Of a particular significance appears to be the position of chopper, of two handaxes, of a kind of a flint hammerstone and of a denticulated flake very close to the upturned mandible, which represents, in this area, the only large sized faunal element not lying in anatomical position and clearly intentionally displaced from its original position.

3. CONCLUSIVE CONSIDERATIONS

As it is well known, several examples of utilization of entire or partial carcasses of large animals (elephant and hippopotamus) have been documented in association with Oldowan, Acheulean and Lower Palaeolithic (*sensu lato*) tools, such as for example at Barogali in Djibuti (Chavaillon *et al.* 1987; Berthelet 2001), Olduvai in Tanzania (Leakey 1971), Hargufia (Desmond Clark *et al.* 1984) and Gombore II (Chavaillon *et al.* 1979) in Ethiopia, Torralba and Aridos in Spain (Villa 1990), Mwanganda's Village in Malawi (Desmond Clark & Vance Haynes 1970), etc.

Equally well known and well studied in their taphonomic features are the cases of carcasses of either fossil elephants, as for example the *Elephas recki* from Haidalo in Djibuti (Chavaillon *et al.* 1990) or modern ones (Conybeare & Haynes 1984; Haynes 1988), which have not been utilized by humans.

In the case of Notarchirico some considerations suggest the utilization of the skull of *Elephas antiquus* from level A1 by hominids. To summarize, data suggesting such an hypothesis are the following :

- association between the paleontological remains belonging to one single individual and several lithic tools either lying in the proximity or in direct contact with some anatomical remains such as, for example, the mandible;
- very limited post-depositional disturbances;
- anatomical connection of many remains, with the unique important exception of the mandible;
- possibility of refitting of several faunal remains.

The hypothesis of a possible utilization of the soft parts of the skull (brain, tongue, trunk) seems therefore supported by a satisfying archaeological evidence.

4. REFERENCES

Berthelet, A. 2001. L'outillage lithique du site de dépeçage à *Elephas recki ileretensis* de Barogali (republique de Djibouti). *C. R. Acad. Sci. Paris* 332: 411-416.

Cassoli, P.F., Di Stefano, G., Tagliacozzo A. 1999. I vertebrati dei livelli superiori (A ed ALFA) della serie stratigrafica di Notarchirico. In M. Piperno (ed.), *Notarchirico. Un sito del Pleistocene medio-iniziale nel bacino di Venosa (Basilicata)*: 361-438. Venosa: Osanna.

Cassoli, P.F., Fabbo, G., Fiore, I., Piperno, M., Tagliacozzo, A. 1999. Taphonomic analysis of some levels of the Lower Palaeolithic site of Notarchirico (Venosa, Basilicata, Italy), *Proceedings Kolloquium Die Rolle des Menschen in Faunenakkumulationen des Alt- und Mittelpalaeolithikum Europas*: 153-172. Neuwied.

Cassoli, P.F., Lefèvre, D., Piperno, M., Raynal, J.-P., Tagliacozzo, A. 1993. Una paleosuperficie con resti di *Elephas (Palaeoloxodon) antiquus* e industria acheuleana nel sito di Notarchirico (Venosa, Basilicata). *Atti XXX Riunione scientifica dell'Istituto Italiano di Preistoria e Protostoria*: 101-116.

Chavaillon, J., Berthelet, A., Boisaubert, J.-L., Faure, M., Guerin, C., Warsama, S.A. 1990. Un *Elephas recki* découvert en connexion anatomique à Haidalo près de As Eyla (République de Djibouti). *C. R. Acad. Sci. Paris* 310, II: 441-446.

Chavaillon, J., Boisaubert, J.-L., Faure, M., Guerin, C., Nickel, B., Poupeau, G., Rey, P., Warsama, S.A. 1987. Le site de dépeçage pléistocène d'un *Elephas recki* de Barogali (République de Djibouti): nouveaux résultats et datation. *C. R. Acad. Sci. Paris* 305, II: 1259-1266.

Chavaillon, J., Chavaillon, N., Hours, F., Piperno, M. 1979. From Oldowan to Middle Stone Age at Melka Kunturé. Understanding Cultural Changes. *Quaternaria* 21: 87-114.

Conybeare, A. & Haynes, G. 1984. Observations on elephant mortality and bones in water holes. *Quaternary Research* 22: 189-200.

Desmond Clark, J., Vance Haynes, C. Jr. 1970. An elephant butchery site at Mwanganda's Village, Karonga, Malawi, and its relevance for Palaeolithic archaeology. *World Archaeology* 1, 3: 390-411.

Haynes, G. 1988. Longitudinal Studies of African Elephant Death and Bone Deposits. *Journal of Archaeological Science* 15: 131-157.

Leakey, M.D. 1971. *Olduvai Gorge, Excavations in Beds I and II* 1960-1963. Cambridge University Press.

Lefèvre, D., Piperno, M., Raynal, J.-P., Tagliacozzo, A. 1998. Notarchirico. An Early Middle Pleistocene Site in the Venosa Basin. *Anthropologie* XXXVI/1-2: 85-90.

Piperno, M. (ed.), 1999. *Notarchirico. Un sito del Pleistocene medio antico nel bacino di Venosa (Basilicata)*. Venosa: Osanna.

Sala, B. 1999. Nuovi dati sulla microteriofauna di Notarchirico. In M. Piperno (ed.), Notarchirico. *Un sito del Pleistocene medio-iniziale nel bacino di Venosa (Basilicata)*: 439-441. Venosa: Osanna.

Villa, P. 1990. Torralba and Aridos: elephant exploitation in Middle Pleistocene Spain. *Journal of Human Evolution* 19: 299-309.

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The American Mastodon *Mammut americanum* in Mexico

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SUMMARY: Aim of this study is to clarify the occurrence of the American mastodon *Mammut americanum* at the southern portion of its distribution. Twenty-three specimens from 15 localities in Mexico have been recorded, most of them from the Central Plateau, up to an altitude of 1500 meters above sea level, and to the east of the country. In addition, the mammoth *Mammuthus* and the American mastodon are contemporaneous in three localities, and mastodon possible association with man in two localities. Their southernmost record is from Honduras. Our data indicate that the American mastodon is a rare taxon at the southern portion of its distribution, which could be related to the presence and possible feeding overlap with the gomphothere *Cuvieronius*.

1. INTRODUCTION

From 1996 to1998, an electronic database on Late Quaternary mammals of Mexico was developed with a similar structure to the FAUNMAP project in the United States of America. The purpose was to gather, verify and update the records of each mammal taxon in the country. From those data, it was clear that at least three genera within the Order Proboscidea inhabited México during the Late Pleistocene, the mammoth *Mammuthus*, the gomphothere *Cuvieronius*, and the American mastodon *Mammut.* The first two genera were very abundant, while the third is rare, and poorly known due to the scarcity of its remains in the country.

The American Mastodon, *Mammut americanum* (Kerr 1792), is a mammutid (Proboscidea, Mammutidae) with a wide distribution in North America, from Alaska to central Mexico (King & Saunders 1984; Polaco *et al*. 1998; Saunders 1996; Shoshani 1990, Tobien 1996), and an isolated record in Central America (Honduras; Lucas & Alvarado 1991). However, the presence of American Mastodon is not clearly documented or is relatively scarce in the fossil record from México, as it is only known from few localities in the Mexican Plateau (Polaco *et al.* 1998). Here, we present the synthetic knowledge about this unique taxon for the Mexican Pleistocene.

A review was undertaken using various sources: published literature; materials housed in the Instituto Nacional de Antropología e Historia collections, and documents from Chester Stock's archives about his team´s research carried out in Mexico during the 1930's and 1940´s, and presently housed in the Natural History Museum of Los Angeles County (LACM). The objective was to update the known distribution for this species in the southern portion of its range. As a result, the American mastodon was recorded from 15 localities distributed in eight states of the Mexican Republic (Fig. 1).

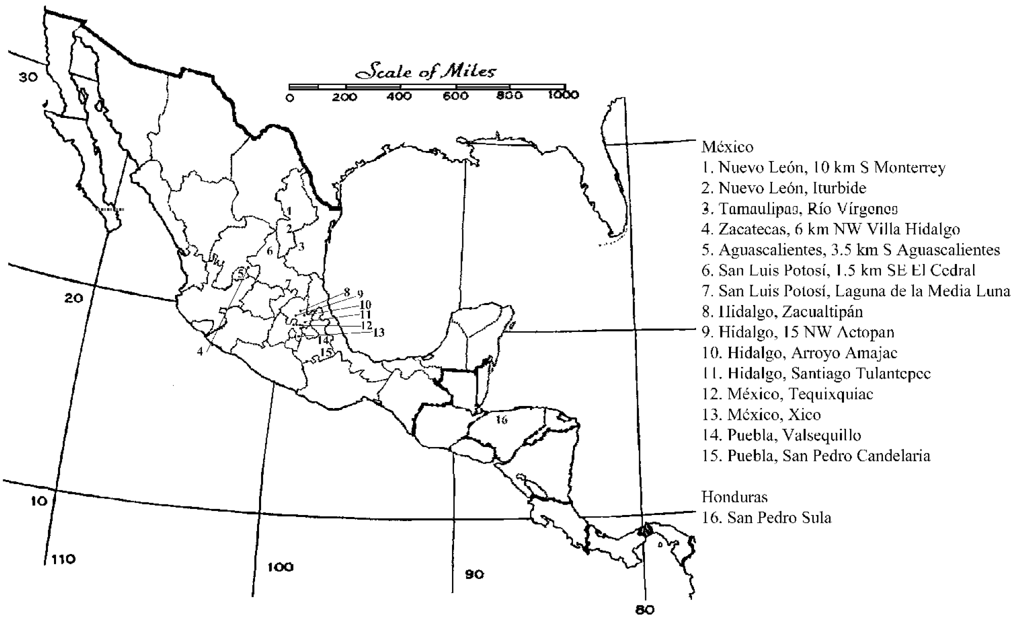

Fig.1 - Known record of *Mammut americanum* south of its southern distribution range (Mexico and Central America).

2. LOCALITIES NUEVO LEÓN

2.1 Nuevoleón

1. - Sierra Alta, La Estanzuela, 10 km south of Monterrey (25° 34 ' 35 " N, 100° 16 ' 34 " W, altitude 601 m (López-Oliva *et al.* in press).

More than 100 bones were recovered, most of them in excellent preservation. They included tusks, molars, mandibles with molars, mandible fragments, ribs, vertebrae, and scapulae from at least 14 individuals within five taxa, *Mammuthus columbi* (2 individuals), *Mammut americanum* (7), *Camelops hesternus* (1), *Bison* sp. (3), and *Equus* sp. (1). Regarding the American mastodon 15 molars or molar fragments, three mandible ramii, and poscranial material were recovered. At least seven individuals were represented.

Molars identification and measurements follow Laub (1992), Miller (1987), and Saunders (1977). The following molar data list indicates kind of teeth, number of elements, total length (mm): average, minimum and maximum, and width (mm): average, minimum and maximum. Dp4 (1) 70.6, 55.1; M1 (1) 50.5, 68.6; M2 (3) 113.6 (108.2-116.6), 88.6 (80.2-94.4); M3 (3) 175.7 (163.6-187.9), 104 (100.9-107.2); m2 (3) 116.3 (104.5-131.5), 87.8 (83-95.2); m3 (5) 183.1 (162.8-200.5), 97.7 (88.1-108.6). The measurements are similar to those provided by Miller (1987) and Saunders (1977).

The presence of *Bison* sp. indicates a Rancholabrean age for the fauna of La Estanzuela. It is the first place in México where the association of *Mammuthus columbi* and *Mammut americanum* has been clearly documented. The possible transverse marks on one mammoth scapula suggest human presence at the time of deposition of the proboscidean remains (López-O. *et al.* 2000).

2. - Iturbide (López-Oliva *et al.* in press).

From this locality, five molars and one lower tusk were recovered. The material was from an approximately 10 year-old young adult mastodon (African age, following Saunders 1977). The measurements of the molars (length vs. width, in mm) are: recently emerged left M2, 128.2, 100.5; unerupted left M3, 195.5, 105.7; worn left dp4, 69.0, 60.5; right m1, 99.2, 74.5; recently emerged left m2, 131.2, 93.6; recently emerged right m2, 128.6, 92.3; inferior tusk with enamel at the tip, 198.8, 24.5. These measurements are similar to those given by Saunders (1977).

2.2 Tamaulipas

3. - Río Vírgenes, at west of Villa Hidalgo and near of the state limits between Nuevo León and Tamaulipas (Miller 1987).

In 1935 molars of the American mastodon were discovered. They are currently housed at LACM. This material is mentioned by Miller (1987). Bode (*in litt.*) refers to this and the discovery of molars of "*Mammuthus* (as *Elephas*)", suggesting that both species coexisted in the same region.

2.3 Zacatecas

4. - Laguna de El Salitre, approx. 6 km NW Villa Hidalgo, altitude 2100 m (Polaco *et al.* 1998).

A left mandible fragment with a complete third molar was recovered. Other bone fragments from the site pertained to mammoth, the Pleistocene horse *Equus*, and the Pleistocene camel *Camelops*. Such an assemblage suggests a Late Pleistocene fauna.

2.4 Aguascalientes

5. - 3.5 km S Aguascalientes (21° 17' N, 102° 5' W) altitude 2000 m.

Mooser & Dalquest (1975) recorded a well-preserved mandible and teeth. The relative age for this fauna is Illinoian or Early Rancholabrean (Montellano-Ballesteros 1992). Ferrusquía-Villafranca (1978) erroneously assigned this material to San Josecito Cave, Nuevo León (Barrios-Rivera 1985). Lucas & Alvarado (1991) also suggested the San Josecito Cave record as the southernmost one for this species.

2.5 San Luis Potosí

6. - Rancho La Amapola, 1.5 km SE El Cedral (23º 49' N, 100º 43' W), altitude 1700 m.

In 1965, two molars were recovered, both right and complete, and with a smooth form. The measurements (length vs. width, in mm) are: M2, 105, 78; M3 131.6, 76.1. New excavations were made in this locality from 1977 to 1983, and additional teeth were discovered. Those were either well-developed or deciduous molars; dp 2 unworn; left dp3 unerupted, 47, 33; right m2, 106.7, 71. In addition, poscranial material was recovered, and included a fibula, a complete axis and vertebrae fragments.

Several springs were in the region at the end of the Pleistocene. Current vegetation is scrubland, but the late Pleistocene vegetation was probably different due to more humid conditions. Three different faunal stages were defined for the age intervals, including those between 30,000 and 25,000 years BP, around 15,000 years BP, and between 10,000 to 8,000 years BP. However, this material could not be allocated to these intervals. While *Mammut americanum* and *Mammuthus columbi* coexisted at this locality, mastodon was the most abundant. Although evidence was found of human presence, it was not associated with mastodon.

7. - Laguna de la Media Luna, near Río Verde, altitude 1020 m (López-Oliva *et al.* in press).

A partial cranium with two molars and basal fragments of two tusks were recovered. Measurements of a left M2 were: 117.3-106.2. Several other animals were recovered from the lake bottom, including *Canis latrans, Procyon lotor, Mammuthus* sp., *Equus* cf. *mexicanus*, *Platygonus* sp., *Camelops* sp., Tanupolama sp., *Odocoileus virginianus*, *Antilocapra Americana*, and *Hydrochoerus* sp. (Hernández Junquera 1977).

2.6 Hidalgo

8. - Zacualtipán.

This locality was the first known in Mexico, and recorded by Freudenberg, (1922). The specimen apparently was a right M1 (Hay 1925). The reported measurements in mm are: length, 85; width, 58.

9. - Minas Anaya, 15 km NW Actopan (Castillo Cerón *et al.* 1996).

A cranial fragment with maxilla and a complete mandible were recovered. Castillo Cerón *et al.* (1996) assumed a late Pleistocene age for the deposit.

10. - Arroyo Amajac (GPS 20° 18’ 18’’ N, 98° 42’ 44,4’’ W, altitude 1860 m).

This locality was mentioned by Miller (1987) based on material housed at the LACM. It was discovered in the 1930's, and at least two skeletons of American mastodon were recovered (Bliss in *litt.*).

11. - Santiago Tulantepec Municipality.

Cabral-Perdomo (2000) recorded at least two individuals which were of different ages, after the cranial and poscranial remains found.

2.7 Estado de Mexico

12. - Tequixquiac (Pichardo del Barrio 1961).

This locality is one of the best known paleontological locality in Mexico, although much of the material was collected from the surface, and only a very few controlled excavations have been done (Hibbard 1955). Pichardo del Barrio (1961) illustrated an isolated upper (left M3) from such locality. However, Hibbard (1955) did not study any specimen pertaining to this taxon, but recorded a third molar without locality data.

13. - Xico (300 m at south of Xico, 8 m profundity).

In 1967 a right M2 practically unworn was recovered. Measurements: length 114.49 mm; width 74 mm.

2.8 Puebla

14. - Valsequillo Area.

The first report of mastodon from this locality was by Irwin-Williams (1967), although a complete description of the remains is lacking to assure its identification as American mastodon, and not as a gomphotherid (Polaco *et al.* 1998). Pichardo (1997) identified the remains as *Mammut americanum* from El Horno and Hueyatlaco localities, with dates of 9150 ± 500 BP, and between 21,000 ± 1500 and 26,000 ± 530 BP. These remains are the first dated materials for this species in Mexico. For a mastodon third molar from El Horno locality, Pichardo (2000) recorded a date of 280,000 BP, without any doubt the earliest presence of this taxon in a Mexican locality. However, Graham (in *litt.*) studied the Valsequillo materials, identifying both mastodon and gomphotherid bones and, in the case from El Horno, he only recorded gomphotherid remains. The identity of the remains dated by Pichardo (2000) warrants further investigation.

15. - San Pedro Candelaria, near of Cd. Serdán.

Pichardo (1961) mentioned a third lower molar. This molar has five lophs and a talonid. For *Mammut americanum*, this character pertains to species variation.

3. CONCLUSIONS

The American mastodon is known by 23 specimens from 15 localities in Mexico. Most of them are found in localities up to 1500 m in the Central Plateau. Except those from Monterrey and Río Vírgenes, all of them are from the eastern part of the country. In three localities (Río Vírgenes, Monterrey and El Cedral), the contemporaneous presence of mastodon and mammoth is recorded. In two localities (Monterrey and El Cedral), human occurrence is possible. The southernmost record in Mexico for the species is at San Pedro Candelaria, Puebla (written as “Pueblo” by some authors), but in the continent, the southernmost and isolated record is from San Pedro Sula, Honduras (Lucas & Alvarado 1991).

From these data, it is clear that the American mastodon was very rare in its southern distribution range. This situation might be correlated with the presence of South American forms of the gomphothere *Cuvieronius*, with which *Mamut* could have overlapped in terms of habitat and feeding preferences.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

Barrios-Rivera, H. 1985. *Estudio analítico del registro paleovertebradológico de México*. Tesis de Licenciatura. Facultad de Ciencias, Universidad Nacional Autónoma de México.

Cabral-Perdomo, M. A. 2000. Presencia de *Mammut americanum* (Proboscidea: Mammutidae), en sedimentos del Pleistoceno Tardío del noreste de la Cuenca de México. In J. G. López Oliva, J. A. Arz, J. R. Chapa Guerrero, T. Cossio Torres, H. De León Gómez, F. Medina Barrera & J. A. Ramírez Fernández (eds.), *VII Congreso Nacional de Paleontología y I Simposio Geológico en el Noreste de México. 22-28 de julio 2000. Libro de Resúmenes*: 15-16. Universidad Autónoma de Nuevo León.

Castillo Cerón, J. M., Cabral Perdomo M. A. & Carranza Castañeda O., 1996. *Vertebrados fósiles del Estado de Hidalgo*. Universidad Autónoma del Estado de Hidalgo, Pachuca.

Ferrusquía-Villafranca, I. 1978. Distribution of Cenozoic vertebrate faunas in Middle America and problems of migration between North and South America. In I. Ferrusquía-Villafranca (ed.), Conexiones terrestres entre Norte y Sudamérica: 193-321. *Universidad Nacional Autónoma de México, Instituto de Geología, Boletín* 101: 1-329.

Freudenberg, W. 1922. Die säugetierfauna des Pliocäns und Postpliocäns von Mexiko. II. Teil: Mastodonten und Elefanten. *Geologische und Palaeontologische Abhandlungen* 14: 103-176.

Hay, O. P. 1925. Extinct proboscideans of Mexico. *The Pan-American Geologist*, 44: 21-37.

Hernández Junquera, A. 1977. *Fauna local Laguna de la Media Luna, Pleistoceno Tardío, Municipio de Río Verde, San Luis Potosí, México*. Tesis de Licenciatura. Facultad de Ciencias, Universidad Nacional Autónoma de México.

Hibbard, C. W. 1955. Pleistocene vertebrates from the Upper Becerra (Becerra Superior) Formation, Valley of Tequixquiac, Mexico, with notes on other Pleistocene forms. *Contributions from the Museum of Paleontology, University of Michigan*, 12: 47-96.

Irwin-Williams, C. 1967. Associations of early man with horse, camel, and mastodon at Hueyatlaco, Valsequillo (Puebla, Mexico). In P. S. Martin & H. E. Wright, Jr. (eds.), *Pleistocene extinctions: the search for a cause*: 337-347. New Haven and London: Yale University Press.

King, J. E. & Saunders, J. J. 1984. Environmental insularity and the extinction of the american mastodon. In P. S. Martin & R. G. Klein (eds.) *Quaternary extinctions: a prehistoric revolution*: 315-339. The University of Arizona Press.

Laub, R. S. 1992. Positional and ordinal identification of the teeth of *Mammut americanum*. *Current Research in the Pleistocene* 9: 105-108.

López-Oliva, J. G., Polaco, O. J., Arroyo-Cabrales J., & Corona-M. E., In press. New records of the American Mastodont in Northeastern Mexico. *Current research in the Pleistocene*. (submitted)

López-O., J. G., Polaco, O. J., Arroyo-Cabrales, J., Corona-M., E., Kouzoub, N., Méndez, S., Sada-G., P., de La Fuente, A., Ramos-L., A., Treviño-C., A., & Rodríguez-S., P., 2000. Vertebrados fósiles de la Sierra Alta en La Estanzuela, sur de Monterrey, Nuevo León, México. In J. G. López Oliva, J. A. Arz, J. R. Chapa Guerrero, T. Cossio Torres, H. De León Gómez, F. Medina Barrera & J. A. Ramírez Fernández (eds.) *VII Congreso Nacional de Paleontología y I Simposio Geológico en el Noreste de México. 22-28 de julio 2000. Libro de Resúmenes*: 105-106. Universidad Autónoma de Nuevo León.

Lucas, S. G. & Alvarado, G. E. 1991. El hallazgo más austral de un *Mammut americanum*: el caso del mastodonte de San Pedro Sula, Honduras. *Revista Geología de América Central* 13: 85-89.

Miller, W. E. 1987. *Mammut americanum,* Utah's first record of the American

Mastodon. *Journal of Paleontology* 61: 168-183.

Montellano-Ballesteros, M. 1990 (1992). Una edad del irvingtoniano al rancholabreano para la fauna Cedazo del estado de Aguascalientes. *Instituto de Geología, Revista* 9: 195-203.

Mooser, O. & Dalquest, W. W. 1975. Pleistocene mammals from Aguascalientes, Central México. *Journal of Mammalogy* 56: 781-820.

Pichardo del Barrio, M. 1960. Proboscídeos fósiles de México: una revisión. Instituto Nacional de Antropología e Historia, *Serie Investigaciones* 4 (1961): 1-63.

Pichardo, M. 1997. Valsequillo biostratigraphy: new evidence for Pre-Clovis date. *Anthropologischer Anzeiger* 55: 233-246.

Pichardo, M. 2000. Redating Iztapan and Valsequillo, Mexico. *Radiocarbon* 42: 305-310.

Polaco, O. J., Arroyo-Cabrales J. & García-Uranga, B., 1998. The American Mastodon in Mexico. *Current Research in the Pleistocene* 15: 122-124.

Saunders, J. J. 1977. Late Pleistocene vertebrates of the Western Ozark Highland, Missouri. *Illinois State Museum, Reports of Investigations* 33: 1-118.

Saunders, J. J. 1996. North American Mammutidae. In J. Shoshani & P. Tassy (eds.) *The Proboscidea: evolution and palaeoecology of elephants and their relatives*: 271-279. Oxford: Oxford University Press.

Shoshani, J. J. 1990. Distribution of *Mammut americanum* in the New World. *Current Research in the Pleistocene* 7: 124-126.

Tobien, H. 1996. Evolution of zigodonts with emphasis on dentition. In J. Shoshani & P. Tassy (eds.) *The Proboscidea: evolution and palaeoecology of elephants and their relatives*: 76-85. Oxford: Oxford University Press.

Taphonomy of *Stegodon orientalis* at Panxian Dadong, a Middle Pleistocene site in Guizhou, South China

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SUMMARY: Panxian Dadong is a large karstic cave in the mountains of western Guizhou province. Archaeological excavations at Dadong have yielded a rich faunal sample in association with stone artifacts and human remains. *Stegodon orientalis* is an important component of the faunal sample, which is predominated by large-bodied mammals. This study was initiated with three main objectives: 1) to describe the sample of stegodont dental and skeletal material, 2) to develop a set of characteristics which can be used to identify fragmentary stegodont dental material, and 3) to produce an age at death profile for the stegodont sample. Ultimately, this study is intended to support other taphonomic and zooarchaeological studies undertaken at Dadong with the goal of determining how faunal material was introduced to the cave.

1. PANXIAN DADONG FAUNA

1.1 Age and composition

The Dadong faunal sample consists of a variety of species characteristic of southern China. A Middle Pleistocene age is verified by U-series and ESR dates ranging between 130-250 ka for the archaeological layers (Shen *et al.* 1997, Rink *et al.*, in press). The sample is predominated by large-bodied animals that would not ordinarily inhabit caves, such as *Stegodon orientalis*, *Rhinoceros sinensis*, and the giant tapir *Megatapirus augustus*, and a diversity of bovids and cervids. The most commonly identified species in the sample is *Rhinoceros sinensis*, which comprises 24% of the total elements identifiable to taxon, followed by *Stegodon* at 13%.

1.2 The stegodont component

The sample consists of 215 isolated or fragmentary teeth, four skull fragments, and 45 postcranial elements. The postcrania include 8 axial elements and 37 appendicular elements. Based on the number and representation of skeletal elements and their stratigraphic positions, the minimum number of stegodonts preserved at Dadong is three. The number and diversity of dental remains suggests that a greater number of individuals is represented.

2. ANALYSIS OF THE STEGODONT DENTITION

2.1 Methodology for identifying fragmentary specimens to specific tooth classes

The fragmentary nature of the Dadong stegodont dental remains complicates their identification to specific tooth classes. In this study, the tooth class designations dp2, dp3, dp4, M1, M2, and M3 are used. To assist in tooth class assignment, the Dadong material is compared with the Yanjinggou sample from Sichuan province (Colbert & Hooijer 1953).

Specimens were initially separated into two groups: those identifiable to class (Group 1, N=41) and those unidentified to class (Group 2, N=174). The majority of deciduous premolars in Group 1 were identifiable to quadrant, although it was difficult to identify molars by element and position. For most purposes in this paper, they are grouped together.

Each Group 1 specimen was described, drawn, photographed, and measured. The results of the analysis of the Group 1 specimens were then used to evaluate Group 2. Variables used included: mesiodistal tooth length, crown height, maximum crest height, base to crest along midline, crest length (buccolingual diameter of each crest), crest width at lateral edges, crest width at midline, enamel thickness at crest apex, enamel thickness at midpoint of crest face, number of conelets, crest occlusal wear score, dentin exposure score, and calculus thickness score.

Penultimate ridge crest height, a measurement Colbert and Hooijer (1953) used to characterize teeth by class, shows progressive increase between successive tooth classes. For the Dadong sample, this variable is a fairly effective discriminator between tooth classes, but several successive classes have overlapping ranges. It was therefore necessary to use several measures to confidently assign the fragmentary Group 2 specimens to tooth class (Tab. 1).

Group 1 is dominated by deciduous premolars, while Group 2 contains a greater number of molars. For those teeth that can be identified to a quadrant, the numbers of maxillary and mandibular teeth are approximately equal. Based on table 1, the largest class is dp4, with a total of 47 specimens. This would mean an MNI of 12 stegodonts.

As many specimens in Group 2 could only be distinguished as premolars or molars, it is also useful to look at a simplified distribution (Tab. 2). This increases the number of both dps and molars identified to general class groupings. The far greater number of dps, (evident in either table, but especially in table 2), suggests that the Dadong fauna has predominantly young stegodonts.

Tab.1 - Tooth Class Distribution.

Tooth	Group 1	Group 2	Total
dp2	13	4	17
dp3	15	30	45
dp4	9	38	47
M	4	48	52
Tusk	0	1	1
Tooth germs	0	4	4
Unidentified	0	49	49
	41	174	215

Tab.2 - Generalized Tooth Class Distribution.

Tooth	Group 1	Group 2	Total
dp	37	93	130
M	4	48	52
Unidentified	0	28	28
Tusk	0	1	1
Tooth germs	0	4	4
	41	174	215

The differing tooth class profiles for Group 1 and Group 2 reflect two biases that are associated with use of fragmentary stegodont material. It appears that the small, dense dp2s have a greater possibility of being recovered in relatively complete form. Teeth with greater numbers of crests are more likely to be recovered as fragments. In the Group 1 sample, 92% of the dp2s are complete, while only 40% of the dp3s, 33% of the dp4s, and none of the molars are complete.

2.2 Determination of dental age and construction of a dental age profile

Following Haynes (1991), we assign specimens to one of five 12-year age categories. Our dental age profile represents the developmental age of source individuals, but because some of the record may be made up of teeth shed naturally, it is not really an age at death profile. It is an age of dental remains profile. The lack of distinction among molars means specimens that potentially belong in older age categories cannot be aged, and are absent in the profile. In addition, each specimen that cannot be refit or associated with other teeth is considered to represent an individual. If all the teeth identifiable by class are assigned to an age category in Haynes's system, all but two fall into the first category (0-12 yrs). There are clearly some other adult individuals, represented by fragmentary molars and two fairly complete M3s, but it is not possible to assign them to a specific category of animals over 12 years of age. This makes it difficult to interpret the sample in terms of model mortality profiles.

3. Evidence for Human activity and selection of Stegodonts

3.1 Mortality profiles

Haynes (1991) describes four distinct mortality profiles for proboscideans. Type A shows the greatest portion of individuals in the first category of subadults with each successive category represented by decreasing proportions. Type B is bimodal, with few prime age adults. Type C is dominated by prime-age adults, and Type D is patternless. The Dadong sample, with its greater preservation of dps, would resemble either Type A or Type B (Haynes 1991). Even if it were possible to assign the 52 molars to age categories, the sample would still have a distribution that has predominantly younger individuals. This assumes that no portion of the sample has been preferentially removed through excessive breakage or other taphonomic factors.

3.2 Accumulation and transport factors

Stegodont material at Dadong may have accumulated through the natural death of animals, the natural loss of deciduous teeth, water transport, predation by large carnivores or humans, or transport by porcupines. From analysis of the dental remains, it appears that there was differential selection of younger animals. While several activities might produce this distribution, human activity may have played an important role. Carnivores are rare at Dadong (4% of the sample identifiable to taxon), and there are few that would have preyed upon animals the size of stegodonts. Bone-collecting porcupines would have had difficulty transporting all but the smallest Stegodont elements. Human activity is well documented at Dadong. Stone tools and human teeth are present in levels with stegodont materials (Schepartz *et al.*, in press). Locally available chert, basalt and limestone were used to make flake tools. Retouch is not intensive on most of the tools and classic Levallois features are not present. No evidence of processing has been found on stegodont bones, but cutmarks, percussion damage and burning are evident in other portions of the faunal assemblage. There is also evidence for selective transport of large mammal appendicular elements (Schepartz et al. in press), and the possible use of rhinoceros teeth as raw material for tools (Miller-Antonio *et al.* 2000).

4. Conclusions

Analysis of stegodont dental and skeletal material illustrates that the Dadong sample consists primarily of younger individuals aged 0-12 years. A combination of tooth measures and morphological characteristics was used to identify fragmentary specimens and increase the analytical sample. This study supports the results of other taphonomic work that suggests humans played an important role in the formation of the Dadong faunal assemblage.

5. REFERENCES

Colbert, E.H. & Hooijer, D.A. 1953. Pleistocene mammals from the limestone fissures of Szechwan, China. *Bull. Amer. Mus. Nat. Hist.* 101:1-135.

Haynes, G. 1991. *Mammoths, Mastodonts, and Elephants*. Cambridge: Cambridge University Press.

Miller-Antonio, S., Schepartz, L.A. & Bakken, D. 2000. Raw material selection and evidence for rhinoceros tooth tools at Dadong Cave, southern China. *Antiquity* 74: 372-379.

Rink, W.J., Schepartz, L.A., Miller-Antonio, S., Huang, W., Hou, Y., Bakken, D., Richter, D., & Jones, H.L. in press. Electron spin resonance (ESR) dating of tooth enamel at Panxian Dadong cave, Guizhou, China. In C. Shen & S.G. Keates (eds.) *Current Research in Chinese Pleistocene Archaeology*. Oxford: BAR Monograph Series.

Schepartz, L.A., Bakken, D., Miller-Antonio, S., Paraso, K., & Karkanas, P. in press. Faunal approaches to site formation processes at Panxian Dadong. In C. Shen & S.G. Keates (eds.) *Current Research in Chinese Pleistocene Archaeology*. Oxford: BAR Monograph Series.

Shen G., Liu J. & Jin L. 1997. Preliminary results on U-series dating of Panxian Dadong in Guizhou province, S-W China. *Acta Anthro. Sinica* 12: 221-230.

Late Middle Pleistocene Mammoths and Elephants of the Thames Valley, Oxfordshire

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SUMMARY: Mammoths and straight-tusked elephants have been excavated from gravel deposits at Stanton Harcourt near Oxford. These two species are stratigraphically contemporaneous and associated with vegetation, molluscs and insects indicative of fully interglacial conditions equated with part of OIS 7 (c.200,000 BP). This association raises interesting questions regarding the habitat and behaviour of the mammoths and elephants and their interaction with the other large ungulates represented at the site. The mammoth is an early form with distinctive dental characteristics. It is known from several British sites believed to be of similar age to Stanton Harcourt but, at these sites, samples are small and stratigraphic information generally poor or non-existent. It was thus of great interest that another gravel deposit, at Latton, approximately 30km west of Oxford, turned up numerous remains of this mammoth, again associated with an interglacial fauna. Both sites have Lower Palaeolithic artefacts although, on account of the fluvial nature of the deposits, none can be said to be functionally associated with the bones. As the analysis of the material from both excavations is far from complete, this contribution hopes to present an informative summary of interesting aspects of these large vertebrate faunas, concentrating particularly on the mammoths and elephants.

More than 1000 remains of an early form of mammoth Mammuthus primigenius in association with those of straight-tusked elephant Palaeoloxodon antiquus have been excavated from an ancient river channel at Stanton Harcourt near Oxford, England (Fig. 1). The river is believed to be the Thames, following a previous course slightly north of its present position and the age of the fossil-bearing deposits is estimated at c.200,000 years BP (OIS 7). The molluscs, insects and abundant vegetation including large logs of deciduous trees such as oak, indicate fully interglacial conditions. This would be the expected environment of the straight-tusked elephant whereas, until relatively recently, mammoths would have been taken to indicate a cool, even cold, environment. Only a decade ago, when the very possibility of an interglacial equated with OIS 7 was still a matter of dispute, there was unequivocal evidence at Stanton Harcourt of the contemporaneous occurrence of elephant and mammoth with a fully temperate fauna and flora. This mammoth, the most common of all the species at Stanton Harcourt, is now widely recognised as a key species in the recognition of OIS 7 interglacial deposits.

At the outset of the excavations some ten years ago, the site was a disused gravel quarry awaiting use as a landfill site. Initial fieldwork had been carried out there some years previously and several bones, plant, insect and mollusc samples had been collected from remnant channel deposits below the main body of commercially extracted gravel. It was proposed that these plant and animal remains had accumulated under interglacial conditions (Briggs *et al.* 1985) and an age of c.200,000 years was suggested on the basis of amino-acid epimerization of molluscs from the site (Bowen *et al.* 1989). Thus the Stanton Harcourt Channel was attributed to a hitherto unrecognised interglacial between the Ipswichian and the Hoxnian interglacials, equated with OIS 7. The ensuing controversy over the status of this ‘new’ interglacial is reviewed by Bowen (1999).

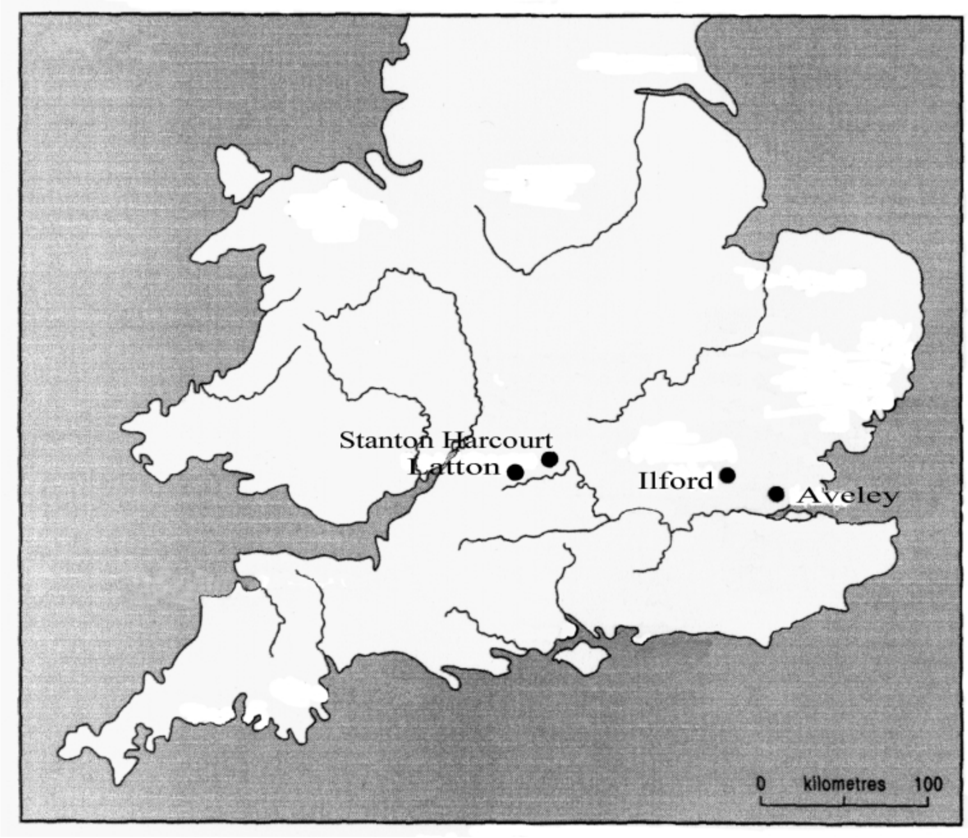


Fig.1 - The Thames Valley sites.

Certainly, when we (the author and C.M. Buckingham) began excavation of the channel deposits, there was widespread doubt among Quaternary specialists as to the age of the site. However, the interglacial issue had less to do with our decision to excavate than did the rare opportunity to retrieve fossils from recorded context with abundant associated biological data. The possibility of finding archaeological material had not been a consideration. In fact, the archaeological evidence for the British Lower and Middle Palaeolithic suggested that the forested environments of the interglacial periods were not conducive to the human occupation of Britain. Thus, the discovery of the first of 27 artefacts among the bones and other fauna and flora at Stanton Harcourt was quite unexpected. Some of these artefacts are weathered and rolled suggesting transport downstream, perhaps from older deposits elsewhere, but others are in quite fresh condition indicating little or no movement since they were discarded in or near the river. Because they occur in fluvial deposits rather than in the strictly *in situ* context of an ancient land surface, it might be argued by some archaeologists that they are derived and therefore invalid as evidence of people during the interglacial. Certainly, it cannot be said that their association with the bones is evidence of hunting or butchery. Nonetheless, as I have discussed elsewhere (Scott 1998), I believe that these unrolled artefacts have the same post-depositional history as many of the large vertebrate remains and therefore indicate the broadly contemporaneous presence of the animals and the people in Britain during the interglacial.

The excavation was concluded two years ago and the lengthy tasks of conservation of bone, analyses of samples and the compilation of field documentation are underway. Two preliminary reports on the excavations have appeared (Buckingham *et al.* 1996; Scott & Buckingham 1997) and a monograph on the site is in preparation. One of the most difficult aspects of preparing a final report on the large vertebrates is their condition. The fact that these remains have survived at all is due to a combination of the alkaline nature of the deposits (the gravel is 95% limestone) and the fact that the underlying clay bedrock caused them to be permanently waterlogged. The latter factor has been enormously influential in the preservation of wood, nuts and even leaves. However, fossilisation of the bones has not taken place and, although teeth are generally in excellent condition, all bones of reasonable size and certainly all tusks have required plaster or fibreglass casing in order to remove them from the site. Of course, this procedure must be reversed before the assemblage can be studied and, apart from the length of time it is taking, there is the possibility that informative damage (cut-marks or animal gnawing) might be obscured in the process. As final numbers and the results of the analyses of environmental samples are not yet available, I propose for the purpose of this conference publication to outline the significance of the material from Stanton Harcourt, concentrating particularly on the mammoths and elephants. Discussion of these remains will include evidence from a smaller, recent excavation at Latton (Scott & Buckingham 2001).

Most importantly, the finds from Stanton Harcourt were excavated. The majority of mammoth remains in Britain result from gravel extraction or from dredging in the North Sea. In such circumstances there is little or no contextual data. At Stanton Harcourt the fossil-bearing deposits were approximately a metre thick and, as access was possible over an area of several acres, detailed recording was possible. When first identified as a site with interglacial fauna and flora, it became known as the Stanton Harcourt Channel (Briggs *et al*. 1985). This term has remained in the literature although, strictly speaking, it is not a single channel but the result of successive episodes of infilling by the ancient river within a wider channel depression cut into the Oxford Clay bedrock. Thus the fossil-bearing deposits are not uniformly distributed. Excavations revealed that in some areas of the site they had evidently been lain down by the ancient river under high energy conditions; in these areas the bones, vegetation, and other remains were observed to be less abundant and more fragmentary. Other areas had evidently been marginal to banks and had been little disturbed by the movement of the water; in these circumstances, beds of molluscs were excavated in their life-death situations, vegetation was dense, logs and branches were jumbled together, and some bones were in close association

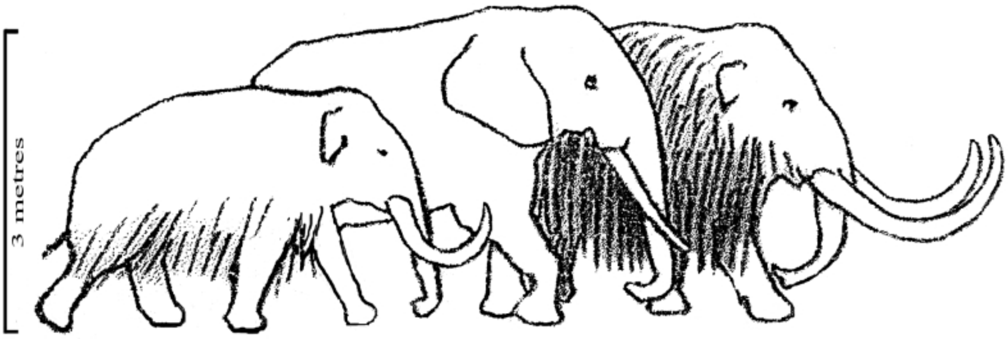
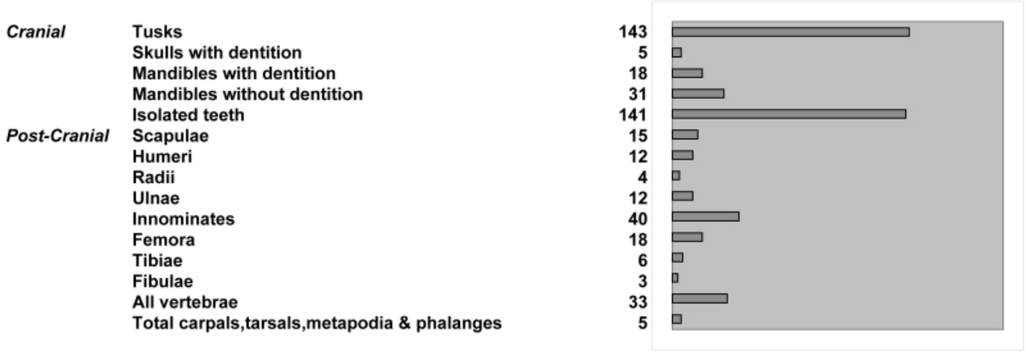


Fig.2 - Artist's reconstruction of the mammoth from Stanton Harcourt and Latton (left), *E. antiquus* (middle) and *M. primigenius* from Ilford (right).

with articulating elements. It is likely that some carcasses lying about on the ground slumped into the river as sections of the bank became undercut and collapsed. It was in these highly organic sediments that some of the least damaged artefacts were found and I propose that they too lay on banks that subsequently collapsed.

As stated above, the mammoth at Stanton Harcourt and Latton is an early form. Three features in particular characterise this mammoth: it evidently inhabited Britain in a fully temperate climate, its teeth have a lower lamellar frequency and slightly thicker enamel than the more evolved mammoth of later stages, and it was approximately one third smaller than its cold stage counterpart (Fig. 2). It was first recorded at Ilford (near London) in the mid-19th century by Adams (1877-81), associated with straight-tusked elephant, and has subsequently been identified at various locations in Britain. However, although the mammoth dentition from Ilford has been compared with dentitions from other European sites from an evolutionary and taxonomic point of view (e.g. Lister & Joysey 1992; Lister 1996), the appearance and habitat of this early mammoth has never fully been described. Although Sandford (1925) certainly recognised mammoth teeth "of Ilford form" in collections from Upper Thames gravels, no stratigraphic data existed and, until the Stanton Harcourt excavations, the total number of specimens of this early form was relatively low. Stanton Harcourt now represents by far the largest assemblage in Britain; there are more than 150 teeth (many of which are in mandibles or skulls) and more than 130 tusks were discovered, although their fragile (unfossilized) condition meant that many of these were not be saved. A large number of post-cranial elements – limbs, scapulae, vertebrae and ribs - were recovered, the pelvis (innominate) being particularly well represented (Fig. 3). Notably scarce are the bones of the feet. Although the sample from Latton, also accumulated in fluvial sediments, is considerably smaller (total number of bones is less than 200), the body part representation is similar. It will be one of my principal aims in analysing all this material to discuss the possible roles of predators and/or fluvial activity in the disproportionate representation of mammoth body parts in these assemblages. However, my greatest interest lies in describing the anatomical features of the various bones of this early mammoth, and to document its differences and similarities when compared with the later form.

It should be possible to describe its overall



Note: unidentified limb fragments, ribs and rib fragments number several hundred

Fig.3 - Skeletal elements of the Stanton Harcourt mammoth.

	O.I.S.7c (earlier phase) ***Temperate woodland***	**O.I.S.7a (later phase)** ***Open grassland***	**STANTON HARCOURT**	**LATTON**
HERBIVORES				
Straight-tusked elephant				
Palaeoloxodon antiquus	*************	*************	*************	
Woolly mammoth				
Mammuthus primigenius		*************		
Mammoth (Ilford type)				
Mammuthus primigenius		*************	*************	*************
Merck's rhino				
Stephanorinus kirchbergensis		*************		
Narrow-nosed rhino				
Stephanorhinus hemitoechus		*************		
Woolly rhino				
Coelodonta antiquitatis		*************		
Horse				
Equus ferus	*************	*************	*************	*************
Hippo				
Hippopotamus amphibius				
Fallow deer				
Dama dama	*************	*************		
Giant deer				
Megaceros giganteus		*************		
Red deer				
Cervus elaphus	*************	*************	*************	
Bison				
Bison priscus	*************	*************	*************	
Aurochs				
Bos primigenius	*************	*************		
CARNIVORES				
Spotted hyaena *Crocuta*		*************		
crocuta		*************		
Wolf *Canis lupus*		*************	*************	
Bear *Ursus arctos*		*************	*************	
Lion *Panthera leo*				

Fig.4 - Biochronological scheme of large mammals of OIS 7, in comparison with Stanton Harcourt and Latton mammal occurrences.

proportions and shape. It had the spiralled, curving tusks of its more evolved relative but did it also have the domed head, the humped shoulders and sloping back so vividly featured in illustrations from Palaeolithic to modern times? One question that is unlikely ever to be answered but which is intriguing nonetheless: was this small mammoth woolly?

Our understanding of the geological age of the early mammoth has undergone several revisions. Until relatively recently, the Ilford assemblage was believed to be of Last Interglacial age (Stuart 1982) although Sutcliffe (1975) had argued for a hitherto undocumented temperate phase between the Hoxnian/Holsteinian and the Last Interglacial to account for anomalies within the large vertebrate assemblages from Lower Thames localities, including Ilford. The proposal of the additional interglacial equated with Oxygen Isotope Stage 7 at around 200000 years BP (Briggs *et al.* 1985; Bowen *et al.* 1989) seemed to accommodate the Ilford form of mammoth satisfactorily. However, as science seeks to resolve and simplify the past, so it reveals it to be ever more complex. The large vertebrate assemblages that in Sutcliffe's opinion belonged to a pre-Ipswichian interglacial and then seemed comfortably placed in OIS7 have been reviewed and further sub-divided by Shreve (1997) into two warm phases of Stage 7 separated by a cooler interval. On the basis of her study of 26 faunal assemblages, she defines an earlier temperate woodland phase (7c) having straight-tusked elephant as its only proboscidean, and an open grassland phase (7a) characterised by three proboscideans: straight-tusked elephant, the small (Ilford) mammoth, as well as a more evolved mammoth (Fig. 4). Shreve notes that remains of the Ilford-type mammoth are considerably more numerous in these 7a assemblages than are the other proboscideans. By Shreve's criteria, Stanton Harcourt belongs to this later warm phase, which might be useful in narrowing down the approximate the age of the site but it also raises some interesting questions.

Reference to Figure 4 shows Stanton Harcourt to be relatively impoverished in terms of variety of species and Latton even more so. To some extent, it could be argued that the excavations at Latton covered a relatively small area during a limited excavation period and that further excavation would very likely increase the species list. This would be an improbable explanation for Stanton Harcourt however, which was excavated over several acres during the course of nine years. One might note especially the absence of any species of rhinoceros, in particular the notably interglacial forms: Merck's rhino (*S. hemitoechus*) and the narrow-nosed rhino (*S. kirchbergensis*), both of which Shreve considers to be important members of the Stage 7a faunas. The majority of Shreve's study sites are in the Lower Thames area some 100km east of Stanton Harcourt. It is difficult, given the gently undulating landscape between these two regions, to envisage a physical barrier to the westward movement of various species of rhinoceros, or indeed of aurochs, giant and fallow deer, all absent at Stanton Harcourt. Perhaps the Upper Thames region had a somewhat different vegetation from that of the south-east of Britain throughout OIS7a, one that was insufficient to sustain a greater species diversity than the five ungulates represented. The bison and horse in these OIS7 assemblages are particularly large; perhaps there simply was not sufficient forage available for a greater number of large ungulates. Or perhaps Stanton Harcourt represents a relatively brief period within the interglacial, much shorter than represented at Aveley (Shreve's type site for OIS7). During the gradual development and decline of an interglacial (or of any of the warm phases within it) the ecosystem will have undergone significant changes. At open sites where deep stratigraphy is lacking, perhaps we are presented with a relatively brief moment in that process of environmental change. At Stanton Harcourt, some areas of the excavation were particularly rich in wood (especially oak), fauna in general, and in distinctively interglacial species such as straight-tusked elephant and the fresh-water mollusc *Corbicula fluminalis*. Conversely, some areas with fewer plant and animal remains also tended to have evidence of more rapid deposition of the sediments, perhaps associated with increased rainfall and general climatic deterioration. Details of the geology and sedimentolgy have yet to be finalised with reference to hundreds of recorded sections. There is no indication of a break in sediment deposition signifying separate climatic events, nor is there any way of knowing the length of time represented by the deposits, but our overall impression is that stratigraphically older deposits represent a slightly warmer environment than younger ones. At Latton we conclude (Scott & Buckingham 2001) that a much shorter interval of time is preserved than at Stanton Harcourt, perhaps late in the interglacial. Here the deciduous woodland and straight-tusked elephant have already disappeared, as has the warm water *Corbicula fluminalis*, to be replaced by cooler, open grassland conditions, evidently the ideal habitat for herds of mammoth and horse.

There is little doubt that the large vertebrates and their environment will be better understood once the richly organic sediment samples have been analysed and collated with the stratigraphic data. The associated fauna and flora is of outstanding quality. Other large vertebrates include bison *Bison priscus*, horse *Equus ferus*, red deer *Cervus elaphus*, lion *Panthera leo* and bear *Ursus arctos*. Somewhat disappointing is the absence of any small mammals, although sample processing might yet produce some remains. However, their absence is to some extent compensated for by an abundance of other material. There are more than 40 species of mollusc (terrestrial and fluvial), an insect fauna comprised of almost 100 species, and a great variety of seeds, including various nuts. Most noteworthy is the outstanding preservation of wood: there were roots still in their rooted position, branches, and large logs, some 2-3m in length. In all, we envisage a mild climate and a relatively slow moving river flowing through a fairly open landscape with stands of forest in the vicinity.

Another avenue of investigation into the environment at Stanton Harcourt that has produced encouraging preliminary results is the isotopic analysis of some of the dental remains. As part of a doctoral thesis, Jones (2000) carried out isotopic analyses of collagen and enamel fractions from mammoth, elephant, horse and bison molars from Stanton Harcourt. The oxygen isotopes were used to calculate palaeotemperatures and the data from Stanton Harcourt exhibit average annual temperatures ranging from similar to the present to cooler by 6-7 degrees C. Carbon isotopic data from both collagen and enamel fractions indicate a 100% C3 diet (both grazing and browsing). Nitrogen isotope data from the collagen fractions of the mammal molars are indicative of water stress within the animal, usually associated with aridity. Cooling and increased aridity are often associated with the onset of glacial periods thus the isotopic data raise the possibility that the final stages of OIS7 are represented at Stanton Harcourt. Jones concludes that the diet of all the animals in the Stanton Harcourt sample was similar but different from that of mammoths in her sample from known cold-stage contexts. This study included only 5 teeth from Stanton Harcourt but the initial results look so promising that further analysis is planned from a wider range of depositional contexts.

There are undoubtedly many aspects that have yet to be documented from this site, which presently represents the richest combined flora and fauna from a British site of OIS7 age. The sample of mammoths and elephants is exceptional. It is anticipated that once these species can be fully interpreted in the context of the abundant plant, mollusc and insect remains from the site, we will have a rare insight into that particular interglacial.

REFERENCES

Adams, A.L. 1877-1881. *Monograph of the British Fossil Elephants*. London: Palaeontographical Society.

Bowen, D.Q., Hughes, S.,Sykes, G.A. & Miller, G.H. 1989. Land-sea correlations in the Pleistocene based on isoleucene epimerization in non-marine molluscs. *Nature* 340: 49-51.

Bowen, D.Q 1999. On the correlation and classification of Quaternary deposits and land-sea correlations. In: D.Q. Bowen, (ed.) *A revised correlation of Quaternary deposits in the British Isles*: 1-9. Geological Society Special Report 23.

Briggs, D.J., Coope, G.R. & Gilbertson, D.D. 1985. *The chronology and environmental framework of early man in the Upper Thames Valley: a new model*. BAR British series 137. Oxford: British Archaeological Reports.

Buckingham, C.M., Roe, D.A. & Scott, K. 1996. A preliminary report on the Stanton Harcourt Channel Deposits (Oxfordshire, England): geological context, vertebrate remains and palaeolithic stone artefacts. *Journal of Quaternary Science* 11: 397-415

Jones, A. 2000. Unpublished PhD thesis, Department of Earth Sciences, Oxford.

Lister, A.M. & Joysey, K.A. 1992. Scaling effects in elephant dental evolution – the example of the Eurasian *Mammuthus*. In: P. Smith, & E. Tchernov (eds.) *Structure, Function and Evolution of Teeth*: 185-213. Jerusalem: Freund.

Lister, A.M. 1996. Evolution and Taxonomy of Eurasian mammoths. In: J. Shoshani & P. Tassy (eds.) *The Proboscidea: Trends in Evolution and Paleoecology*: 203-213. Oxford University Press.

Sandford, K.S. 1925. The Fossil Elephants of the Upper Thames Basin. *Quat. Journ. Geol. Soc.* 81: 62-86.

Schreve, D.C. 1997. *Mammalian Biostratigraphy of the Later Middle Pleistocene in Britain.* Unpublished PhD thesis. London: University College.

Scott, K. & Buckingham, C.M. 1997. Quaternary fluvial deposits and palaeontology at Stanton Harcourt, Oxfordshire. In S.G. Lewis & D. Maddy (eds.) *The Quaternary of the South Midlands and the Welsh Marches*: 115-126. London: Quaternary Research Association Field Guide.

Scott, K. 1998. Southern Rivers. In *Stone Age Archaeology*: 110-113. Oxbow Monograph 102. Lithics Studies Society Occasional Paper 6. Oxford.

Scott, K. & Buckingham, C. 2001. Preliminary report on the excavation of late Middle Pleistocene deposits at Latton, near Cirencester, Gloucestershire. *Quaternary Newsletter* 94: 24-29.

Stuart, A.J. 1982. *Pleistocene Vertebrates in the British Isles*. Longman.

Sutcliffe, A.J. 1975. A hazard in the interpretation of glacial-interglacial sequences. *Quaternary Newsletter* 17: 1-3.

Mammal fauna remains in the Middle Pleistocene volcanic deposits from Northeastern Sabatini Volcanic District area (Latium, Italy)

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SUMMARY: This paper describes mammal remains (*Elephas antiquus, Bos primigenius, Cervus elaphus*) contained in lahar deposits from the North-eastern Sabatini Volcanic District (SVD), which have been studied from a volcanological and paleontological point of view. These deposits are characterised by a very discontinuous thickness and crop out in a very small area. The stratigraphical relationship with the Tufo Rosso a Scorie Nere *Auct.* (450 ka) and with the Tufi Varicolori della Storta *Auct.* (410 ka) are based on Plinian pumice and scoria fall deposits which have been used as stratigraphic markers.

1. INTRODUCTION

The Sabatini Volcanic District (SVD) is a large volcanic field characterised by the lack of a central volcano.

Its activity, made of many small centre, spread over a wide area (about 1500 km^2) and its volcanic products outcrop are found from the right bank of the Tiber valley to Rome city. Three main phases of activity have been defined in the literature: a first phase started at 600 ka in the eastern area, near the Morlupo and the Castelnuovo di Porto towns, during which prevailing pyroclastic flows and phreatomagmatic deposits were emplaced.

A second phase started in the central area of SVD, near the Sacrofano town. A new dating of the Tufo Giallo della Via Tiberina, one of the oldest known volcanic deposit in the SVD area, gave an age of 550 ka (Karner *et al*. 2001). This phase ended at 285 ka (Karner *et al.* 2001) with a caldera collapse and the eruption of a pyroclastic flow, the Tufo Giallo di Sacrofano *Auct.*

A pyroclastic flow deposit called Tufo Rosso a Scorie Nere *Auct.* (450 ka, Karner *et al.* 2001) and some pumices and scoriae plinian fall deposits are interbedded with the products of the Sacrofano volcanic centre. The origin of these products has been located within the SVD (Alvarez *et al.* 1975), but the precise eruption locality is still uncertain.

The third phase, opened by the caldera collapse of Sacrofano, shows a progressive increase of magma-water interaction and a migration of the activity towards the Bracciano lake area. The last phreatomagmatic deposit from this last phase is 40 ka old (Karner *et al.* 2001).

Interbedded with these volcanic deposits, there have been various diatomitic deposits and paleosoils, formed during the quiescence phases of volcanic activity.

The field survey of plinian fall deposits here reported is based on the Walker's model (Walker 1973, 1981); tephrostratigraphic correlations follow the method defined by Cas & Wright (1987).

2. GEOLOGICAL SETTING

The lahar deposits, which contain the mammal remains here reported, crop out only in a small area of the northeastern SVD area. Due to the difficulty to correlated directly such lahar horizons, coheval pumice and scoria

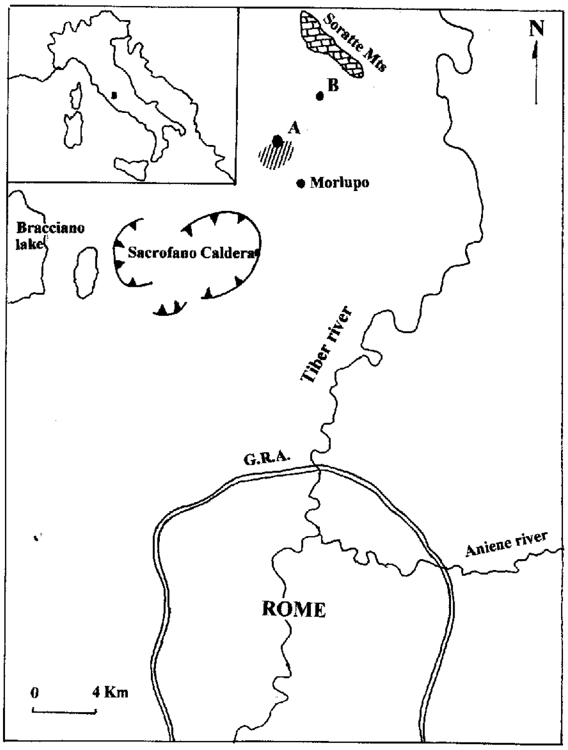

Fig.1 - Location of the Sabatini Volcanic District, North of Rome: The mammal remains area is shown in grey. The sites of stratigraphic columns reported in fig. 2 are indicated with "A" and "B".

plinian fall deposits, outcropping extensively in the SVD area, were used as stratigraphic markers. This tephrostratigraphic correlation allowed the chronology of the lahar deposits, based on the absolute K/Ar dating of two volcanic units: the Tufo Rosso a Scorie Nere Auct. (450 ka, Karner *et al.* 2001) which underlies the lahar, and the Tufi Varicolori della Storta Auct. (410 ka, Karner *et al.* 2001) which are interbedded with them.

2.1 Stratigraphy

The volcanic sequence of the Tufi Varicolori della Storta *Auct.*, which contains the fossiliferous lahar deposits, begins at the top of the Tufo Rosso a Scorie Nere *Auct.* pyroclastic flow deposit (450 ka, Karner *et al.* 2001), and is made of plinian scoriae and pumice fall deposits interbedded with paleosoils, diatomite deposits, lahar deposits, epiclastic deposits, thick idromagmatic deposits with ashy matrix and cross-laminations.

The sequence is topped by the Tufo Giallo di Sacrofano Auct (285 ka, Karner *et al.* 2001).

2.2 Lithological and sedimentological features of the fossiliferous lahar deposits

These lithoid deposits are mainly confined within paleotopographic lows, where they can reach the maximum thickness of 3 m. They are massive, very poorly sorted, with large rounded clasts (<15 cm), contain biotite and augite phenocrists and rounded pumices in a fine-grained ashy, clayey, matrix, alternating with small continuous centimetric reverse-graded levels of well sorted pumice level.

The best preserved mammal remains are found within the fine-grained ashy matrix, probably due to their lower permeability compared to that of fall levels.

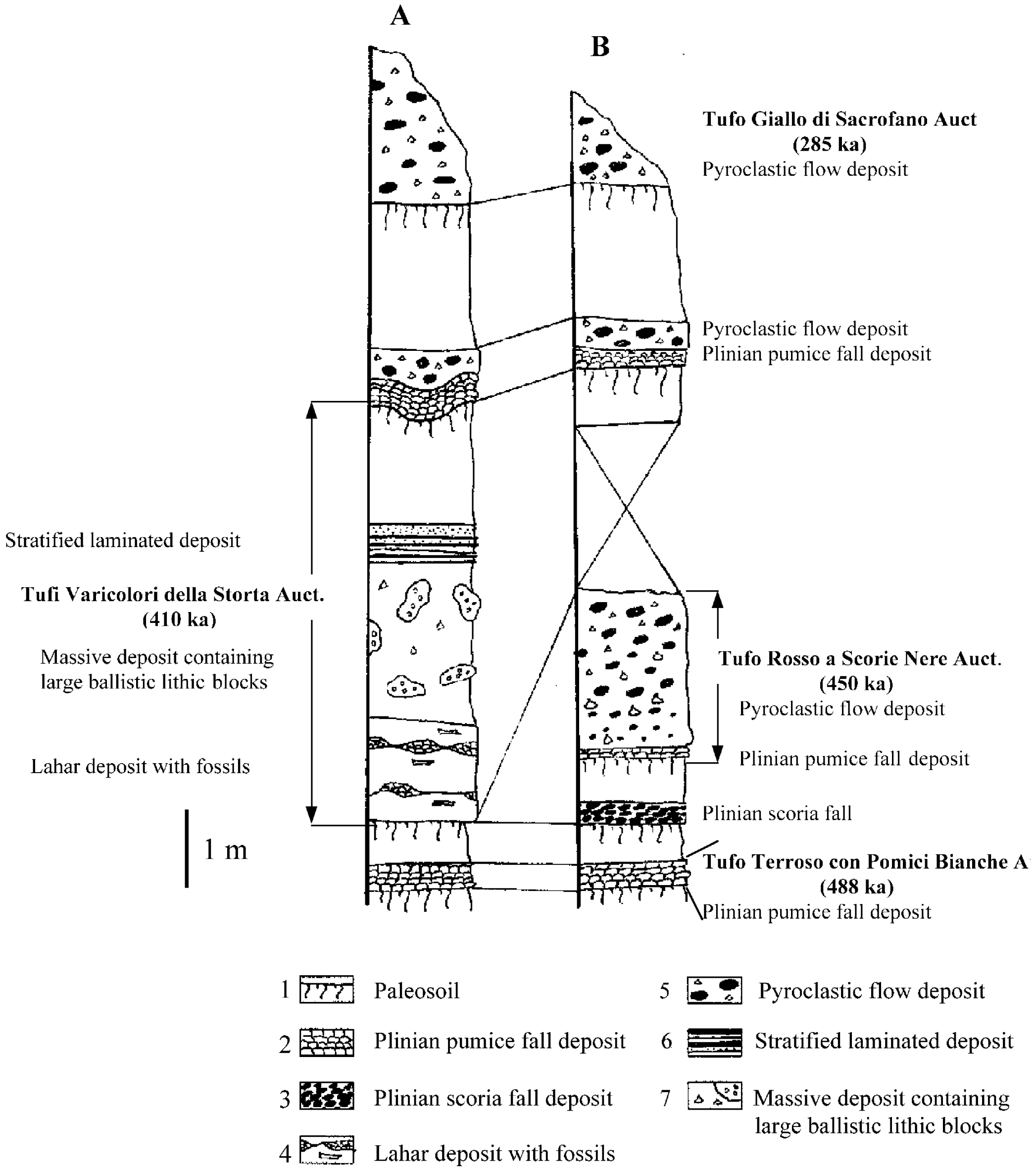

Fig.2 - Stratigraphy of the Northeastern Sabatini Volcanic District.

Fig.3 - *Elephas antiquus*: fragment of molar M³.

3. FAUNA

Three taxa were recognised:

Elephas antiquus with some tusk fragments with Schreeger lines angle of 110° (average value); two fragments of M³. Two fragments probably belonging from the same tooth, possibly of the same individual, some fragments of skeleton of a young individual (fragments of parietal bone, vertebra, ribs, caput femoris, carpal and tarsal bonus). A fragment (Fig. 3) made of five lamellae, the first of these is present only in his posterior side, with a thickness compatible with the molar tooth M³.

The first two plates show clear retroflection on both sides (cfr. Palombo 1986); the other plates are more regular and oval shaped. The enamel is thin (2,02 mm mean value) with many folds, especially in the middle where the folds, on both the side, are very marked, especially in the last three plates where there are additional folds, strongly protruding the dental cement. In the last lamella it's clear the fusion phase with the lateral digitisation at the beginning phase. The second fragment (Fig. 4) is the back part, as the absence of pressure traces on the back wall shows and confirms the origin in M³.

Six lamellae are preserved at the first phase of wear, with digitisation separated or just united. The enamel has a thickness of 2,2 mm (average value) and shows many folds, from which protrudes the central enamel which is

Fig.4 - *Elephas antiquus*: fragment of molar M³.

both on the back and on the frontal wall.

Bos primigenius: represented by a distal epiphysis (?*Bos* sp.,? *Hippopotamus* sp.) and a fragment of a tibia proximal epiphysis.

Cervus elaphus: represented by a fragments of shed antler that does not show any subspecific diagnostic features, a fragment of vertebra, and part of femur distal epiphysis, a fragment of astragalus showing evidence of weathering.

Stephanorinus sp. is represented by a proximal fragment of radius.

4. DISCUSSION AND CONCLUSIONS

The tephrostratigraphic correlation allowed the mammal fauna remains to be to ascribed to the stratigraphic interval 450 - 410 ka.

The morphology of the molar teeth of *Elephas antiquus* is similar to the one described in the Fontana Ranuccio site (458 ka, Celletti 200, Caloi *et al.* 1998).

Their peculiar features are: the central "V" shaped fold, markedly protruding on both walls of lamina; well marked additional folds, even if the morphological and biometric data are comprised in the variability field of the later populations, like the early-Aureliano ones, (Torre in Pietra FU; Palombo, 1986; Palombo *et al.* in press). At this moment, the data collected allow to ascribe the fauna from the volcanic deposits in the north-eastern SVD area to upper Galeriano or early Aureliano.

The study of volcanic deposits from both, the volcanological and paleontological point of view, gives a powerful tool for the knowledge of the Middle-Pleistocene environment of Latium, and of the impact that the paroxysmal phases of volcanic activity had on local fauna.

5. ACNOWLEDGEMENTS

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6. REFERENCES

Alvarez, W., Gordon, A. & Rashak, E.P. 1975. Eruptive source of the "Tufo Rosso a Scorie Nere", a Pleistocene ignimbrite north of Rome. *Geologica Romana* 14: 141-154.

Caloi, L., Palombo, M.R., Zarlenga, F. 1998. Late middle Pleistocene mammal faunas of Latium (Central Italy): stratigraphy and environment. *Quaternary International* 47-48: 77-86.

Cas, R.A.F., Wright, J.W. 1987. *Volcanic successions, modern and ancient*. London: Allen & Unvin.

Cassoli, P.F., Segre Naldini, E. 1984. Nuovo contributo alla conoscenza delle faune Villafranchiane e del Pleistocene medio del bacino di Anagni, Frosinone. In *Atti XXVI Riun. Scient. IIPP*: 115-118.

Celletti, P. 2000. *Resti di proboscidati del Pleistocene medio e superiore delle valli del Sacco e del Liri (Lazio meridionale)*. Tesi di Laurea in Sc. Naturali, Università "La Sapienza" di Roma. 1999-2000.

Karner, D.B., Marra, F., Renne, P.R. 2001. The history of the Monti Sabatini and Alban Hills volcanoes: groundwork for assessing volcanic-tectonic hazards for Rome. *Jour. Vol. Geoth. Res* 107: 185-219.

Palombo, M.R. 1986. Observations sur *Elephas antiquus* Falconer & Cautley du Pléistocène moyen d'Italie: essai d'évaluation des caractères dentaires. *Geologica Romana* 23 (1984): 99-110.

Palombo, M.R., Azanza, B., Alberdi, M.T. (in press). Italian mammal biochronology from latest Miocene to middle Pleistocene: a multivariate approach. *Geologica Romana*.

Walker, G.P.L. 1973. Explosive volcanic eruption: a new classification scheme. *Geol. Rundsch*. 62: 431-436.

Walker G.P.L. 1981, Plinian eruptions and their products. *Bull. Volcanol.* 44: 305-324.

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The Elephants of Terra Amata open air site (Lower Paleolithic, France)

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SUMMARY: The site of Terra Amata has yielded several remains of *Elephas antiquus* in the different anthropic occupation levels. The preservation is not good and doesn't allow to do a morphological study of the remains. The population of *Elephas* is presented in its archaeological context and the principal taphonomic observations are discussed.

1. INTRODUCTION

The Terra Amata open air site is located in the city of Nice (SE of France) in the western slope of Mount Boron, at the altitude of 30 m above modern sea-level. Six months of excavation organised in 1966 by H. de Lumley on about 120 m^2, have uncovered a succession of paleosurfaces with a high concentration of artefacts attributed to acheulean culture (Lumley *et al.* 1976; Villa 1978, Coombs 1997), large mammals bone remains and evidence of structure (fire structure, huts, etc).

The stratigraphic sequence contains about 10 m of deposits. It consists in four principal units, A, B, C1 which contain each other a beach ridge (marine transgression period) covered by a dune (regression period), and on the top of the sequence, the C2 unit, which is only continental. The archaeological levels belong to the C1 unit which is divided in C1a : calcareous clay and marine beach, and C1b : dune (de Lumley *et al.* 1976). The age of these formations is essentially based on the succession of the fossil marine beaches deposited on the Mount Boron. H. de Lumley *et al.* (1976) attributed the marine deposits of Terra Amata to the isotopic stage 11. In 1977, a preliminary thermoluminescence dating realized on two burnt flints from the beach (C1a) have given an age of 214,000 and 244,000 years respectively (Wintle & Aitken 1977). Recently, the ESR dating on quartz sediment from the beach C1a indicates an age of 380,000 ± 80,000 years (Falguères *et al.* 1991).

The mammalian fauna from C1 units consists in *Elephas antiquus, Bos primigenius, Hemitragus bonali, Sus scrofa, Cervus elaphus, Stephanorhinus hemitoechus, Ursus* sp., *Oryctolagus cuniculus* (Mourer-Chauviré & Renault-Miskovsky 1980; Serre 1991; El Guennouni 2001). The size of the rhinoceros of Terra Amata and the degree of hypsodonty is close to the population of Orgnac 3 (stage 9) studied by Aouraghe (1992) (Lacombat pers. comm.). This association is relatively similar in both levels C1a and C1b. The rodents are represented by very few remains, attributed by J. Chaline to *Apodemus sylvaticus, Microtus brecciensis, Arvicola cantianus, Pliomys* sp. The study of amphibians and reptiles shows a large representation of *Malpolon monspessulanus* in all the levels associated to *Testudo hermanni* in the dune C1b; these species are characteristic of a Mediterranean climate and indicate the presence of an open Mediterranean forest (Bailon, pers. comm.). In general, this faunal assemblage corresponds to a warm stage of the Middle Pleistocene. These results are confirmed by the palynological analysis (Mourer-Chauviré & Renault-Miskovsky 1980).

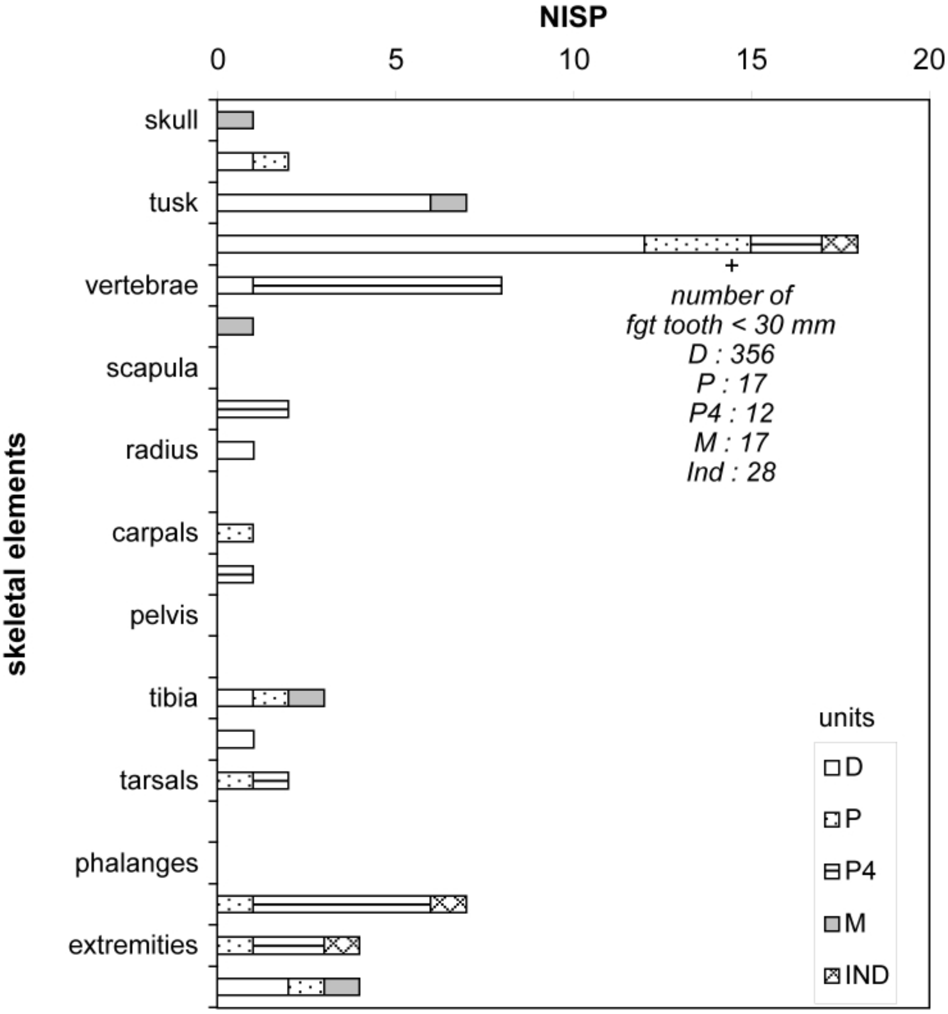

Fig.1 - Elephant skeletal element frequencies per archaeostratigraphic units.

2. MATERIAL AND METHODS

Over 12,000 remains of large mammals have been discovered. The determination ratio is about 20%. Nevertheless, in the dune, there is a particularly large number of very small fragments of Elephant teeth measuring less than 3 cm and which overestimates this ratio and the frequency of this species.

In general, the bone preservation of all the species is not good, and particularly in the beach levels (P unit). The bones show different degrees of alteration on their cortical surfaces and important degree of fragmentation due to anthropic and/or climato-edaphic factors. The revision of all the faunal remains is still in progress and the taphonomic approach is conducted using the principal archaeostratigraphic units (order 1) (Tab. 1) which were established by Pollet (1990). These units are used for the MNI values. The utilisation of the smallest units (order 2 or 3, see table 1) seems to be incorrect because of the interdependence of the levels which has been revealed by the study of the lithic refittings (Villa 1978, 1982). The influence of the choice of the quantifying unit on the MNI values has already been described in the case of Lazaret cave (Valensi 2000). A data base containing all the palaeontological information allow us to carry out the space distribution analysis.

3. PRELIMINARY RESULTS

At Terra Amata, *Elephas antiquus* is one of the best represented species in terms of NISP (25%) and MNI (17%). The distribution of the remains is given per level in table 1. About 30, 32 and 22 remains come respectively from the beach, the P4 unit and the M unit, and 381 remains (specially small molar fragments) from the dune. At least 8 individuals have been counted in using the principal archaeostratigraphic units. We have determined 1 young individual in the M unit, 1 young and 1 adult in the P4 continental unit, 1 very young and 1 adult in the beach (P unit) and 1 very young, 1 young (2-3 years) and 1 adult in the dune (D unit). The population is represented by a majority of juvenile animals. This abundance of non-adults may characterise archaeological sites with a selective capture of juvenile individuals (see Fosse 1998). The representation of the different skeletal elements (Fig. 1) and the very poor representation of polished or rounded bones suggest that water is not responsable of the accumulation or large dispersion of the material (see Voorhies 1969; Behrensmeyer, 1988; Fosse 1994). This observation is confirmed by the study of the spatial analysis (El Guennouni 2001). The frequency of the skeletal elements seems to indicate an early access (hunting or early scavenging) to the elephants and transport to the camp by humans, especially in the marine deposit where the elephants are represented by fragments of skull, mandibles, teeth and some vertebrae, ribs and limb bones.

Only few milk teeth are complete. Cranium, limb bones and teeth of adults are all fragmented. The fragmentation of the bones is due to climato-edaphic conditions (presence of different stages of *weathering*) and in some cases to human activity. Evidence of carcass exploitation by man for food or other activities is difficult to underline. Nevertheless some bones show the presence of percussion pits and green bone fractures. Finally, a non-identifed bone fragment presents one rounded and very polished edge, possibly as a result of a use-wear.

The spatial analysis is still in progress. It seems to indicate that the different archaeological levels correspond to a succession of short occupations. In each archaeological layer, the elephant remains are strongly associated to the others species and the lithic artefacts.

Datations	Stratigraphic units (Lumley, 1976)		Description	Archaeostratigraphic units (Pollet, 1990)			Archaeological material	Fauna
				order 1	order 2	order 3		
	C	C1 b	Dune	D	DA	DA1, DA2, DA3, DA4	hutts, fire structure and very abundant artefacts	very abundant
					DB / SA, SB	DB1, DB2, DB3 / SA, SB		
					DC	DC1, DC2, DC3, DC4		
isotopic stage 11 (Lumley, 1976) 214 -244 Ky (Wintle & al.,1977) 380+- 80 Ky (Falguères & al., 1991)		C1a	Beach	P sup.	P1		abundant	present
					P2			
					P3			
			Continental deposit	P4	P4	P4a, b, c	hutts, fire structure and artefacts	present
			Calcareous clay Alternance of marine and continental deposits	M	M	M1, M3 (clay) M2, M4, M5,M7 (sand) M4G, M6 (pebbles)	present	present

Tab.1 - Description of the archaeostratigraphic levels of the site.

4. CONCLUSIONS

The Lower Palaeolithic site of Terra Amata corresponds to a succession of open air habitats wich have yielded an abundant acheulean industry associated with a middle pleistocene fauna.

Among the large mammals, *Elephas antiquus* is one of the well represented species. The bad preservation of the remains, due to climato-edaphic patterns, doesn't allow to describe the morphological characteristics of the population. The interest of the study is based on the taphonomic approach, knowing the archaeological context of the site. Elephant remains are present in all the levels attributed to anthropic occupations. The preliminary taphonomic results seem to underline a selective capture (by hunting or early scavenging) of young individuals.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Aouraghe, H., 1992. *Les faunes de grands mammifères du site Pléistocène moyen d'Orgnac 3 (Ardèche, France). Etude paléontologique et palethnographique. Implications paléoécologiques et biostratigraphiques*. Thèse de Doctorat du Museum National d'Histoire Naturelle. Paris.

Behrensmeyer, A.K. 1988. Vertebrate preservation in fluvial channels. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 63: 183-199.

Coombs, R. 1997. *Les industries lithiques du Paléolithique inférieur du site de Terra Amata, Nice, Alpes-Maritimes.* Thèse de Doctorat du Muséum National d'Histoire Naturelle. Paris.

El Guennouni, K. 2001. *Les lapins du Pléistocène moyen et supérieur de quelques sites préhistoriques de l'Europe méditerranéenne: Terra Amata, Orgnac 3, Baume Bonne, Grotte du Lazaret, Grotte du Boquete de Zafarraya, Arma delle Manie. Etude paléontologique, taphonomique et archéozoologique*. Thèse de Doctorat du Muséum National d'Histoire Naturelle. Paris.

Falguères, C., Yokoyama, Y. & Quaegebeur, J.-P. 1991. Datation par la résonance de spin électronique (E.S.R.) de sédiments quaternaires. In: Datation et caractérisation des Milieux Pléistocènes, Actes des symposiums 11 et 17 de la 11ème R.S.T., Clermont-Ferrand, 1986, *Cahiers du Quaternaire* 16: 39-52.

Fosse, P. 1994. *Taphonomie paléolithique: Les grands mammifères de Soleilhac (Haute-Loire) et de Lunel-Viel 1 (Hérault)*. Thèse de Doctorat. Université de Provence – Aix-Marseille I.

Fosse, P. 1998. Les Proboscidiens au Paléolithique inférieur: une origine anthropique? In *Economie préhistorique: les comportements de subsistance au Paléolithique, XVIII° Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*: 105-119. Editions APDCA, Sophia Antipolis.

Lumley, H. de, Lumley, M.-A. de, Miskovsky, J.-C. & Renault-Miskovsky, J. 1976. Le site de Terra Amata. In H. de Lumley (ed.), *Sites paléolithiques de la région de Nice et Grotte de Grimaldi, Livret-guide de l'excursion B1, IX° Congrès U.I.S.P.P.*: 53-54. Nice.

Mourer-Chauviré, C. & Renault-Miskovsky, J. 1980. Le paléoenvironnement des chasseurs de Terra Amata (Nice, Alpes-Maritimes) au Pléistocène moyen. La flore et la faune de grands mammifères. *Géobios* 13: 279-287.

Pollet, G. 1990. *Contribution à l'individualisation des sols d'habitat de Terra Amata. Elaboration de lexiques de correspondance, sols d'habitat-couches-objets coordonnés*. Diplôme d'Etudes Doctorales, Museum National d'Histoire Naturelle. Paris.

Serre, F. 1991. Etude taphonomique des restes fossiles du gisement pléistocène moyen ancien de Terra Amata (Nice, Alpes-Maritimes). *L'Anthropologie* 95: 779-796.

Valensi, P. 2000. The archaeozoology of Lazaret cave (Nice, France). *International Journal of Osteoarchaeology* 10: 357-367.

Villa, P. 1978. *Terra Amata and the Middle Pleistocene archaeological record of southern France*. Ph.D. dissertation, University of California. Berkeley.

Villa, P. 1982. Conjoinable pieces and site formation processes. *American Antiquity* 47: 276-290.

Voorhies, M.R. 1969. *Taphonomy and population dynamics of an early Pliocene vertebrate fauna, Knox County, Nebraska* 1.

Wintle, A.G. & Aitken, M.J. 1977. Thermoluminescence dating of burnt flint: application to a Lower Paleolithic site, Terra Amata. *Archaeometry* 19: 111-130.

Reconstruction of mammoth environments at different stages of the Pleistocene in the West-Siberian Plain

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SUMMARY: The data obtained by spores-pollen, carpological, entomological and microteriological analyses from 5 sites in the West-Siberian Plain, where the remains of fossil proboscideans were also found, are discussed within the paper. The results were used for the reconstruction of the environment of proboscideans in this territory for the Early (Chembakchino 94 A), Middle (Chembackhino 94 B) and Late Pleistocene (Nikitino, Ugansky Uval 1290/2, 430th km). The materials obtained allow one to get more specific information about the environment of fossil proboscideans in different regions of the West Siberian Plain and during different stages of the Quaternary period. The environment of the region was mainly a boggy floodplain with a mosaic landscape including tundra, forest and sometimes steppe elements.

1. INTRODUCTION

One of the important aspects in the study of fossil proboscideans from Northern Eurasia is the reconstruction of their environment. In this term the findings of complete mammoth carcasses from permafrost, with excellently preserved food remains in their stomach (Vereshchagin & Mikhelson 1981; Sokolov 1982), are most informative. But they are very rare even in the north of East Siberia. The findings of Quaternary fossil bones of proboscideans are very common in the West Siberian Plain. A comparison of the results of spore-pollen, carpological and palaeoentomological analyses with the evidence of the associated vertebrate fauna allows a detailed and objective reconstruction of the Pleistocene ecosystems where proboscideans lived. Plants, insects, large and small mammals characterize the various energy levels in the structure of ecosystems, and, therefore their distribution is limited by different ecological factors. In taphonomic terms these organisms characterize different processes in the formation of deposits (Borodin *et al.* 1998).

Numerous sites with paleobotanical, entomological (more then 80) and small mammal (about 70) fossil remains are known from the Quaternary deposits of the West Siberian Plain (Borodin 1996). However complex sites with both mammoth and other vertebrates, insects and plants are rare. The present study deals with the results of the investigation of fossil flora and fauna from 5 complex sites in West Siberia.

2. GEOGRAPHICAL POSITION AND THE AGE OF SITES

2.1 Chembakchino-94 A

This site is situated on the right bank of the Irtysh River, at 60°N latitude. The section is about 10 km long - the cliff being over 40 m high. An almost complete skeleton of *Archidiskodon trogonterii* Pohlig, 1885 was found in the deposits of the lower part of section, at a point 7 km from Chembakchino. It was found in a sand-silt lens within a thick bed of grey clay and was accompanied by the remains of small mammals, fossil insects and plant fragments (Borodin *et al.* 1998). These deposits (Semeikian Suite Formation) have been dated by the thermoluminescence (TL) method to 650,000±110,000 years BP in the regional stratigraphical scheme for West

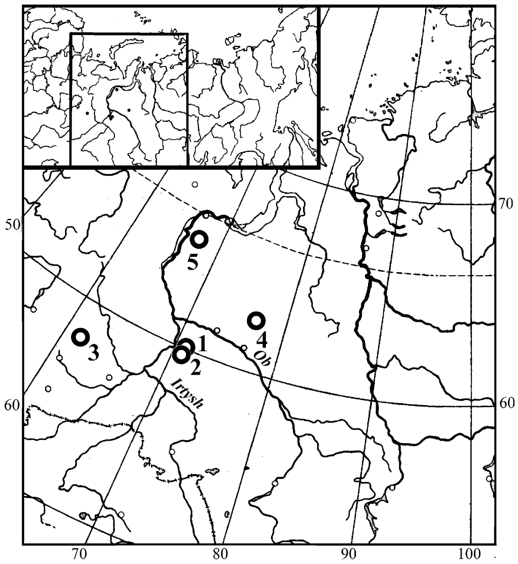

Fig.1 - The geographical position of the sites: 1 - Chembakchino-94 A; 2 - Chembakchino-94 B; 3 - Nikitino; 4 - Agansky Uval 1290/2; 5 - 430th km.

Siberia (Arkhipov 1987). The morphological analysis of the molar teeth of vole fossils implies that the fauna is at least older than the Okian Stage (i.e. older than the Elsterian).

2.2 Chembakchino-94 B

The lower jaw of *Mammuthus* cf. *chosaricus* Dubrovo, 1966 (determination of P.A. Kosintsev, oral report) was found down-stream from the site Chembakchino-94 A in a sand layer located in the deposits of Semeikian suite at a height of 18-25 m. It was accompanied by the remains of small mammals, insects and plants and was incorporated in a sand lens with clayish gravel and formed a lenticular stratified body of fine light-grey sand and plant detritus.

The morphological characteristics of the molars of *Dicrostonyx* (late stages of *D. simplicior* Fejfar,1966) allow one to date this material to the Elsterian. Small mammal fauna of this site are more ancient and essentially poor in species diversity, as compared to the formerly described Chembakchino small mammal fauna deposits, that have been dated by thermoluminescence (TL) method to 313,000±80,000 years BP in the regional stratigraphical scheme for the quaternary deposits of West Siberian Plain (Smirnov *et al*, 1984; Borodin 1996).

2.3 Nikitino

A mammoth (*Mammuthus primigenius* Blumenbach 1799) vertebra was found on an 8-meter cliff on the left bank of the river Kirga (river Tura tributary) in Nikitino (57°N latitude). The remains of plants, insects and small mammals were taken from the sand-silt layers at the depth 5.0-5.8 m. The suggested age is compared to Zyrianian (= Weichselian) time, which can be proved by the morphology of rodent molars.

2.4 Agansky Uval- 1290/2

Bones (2 tusks and ascapula) from woolly mammoth were found in the south-west part of the pit wall, located 8.5 km from the river Kattoyyogan between the rivers Agan and Vakh (right tributaries of the river Ob) at 61°N latitude. From the same layer (1.0-3.0 m of depth), formed by sand-silk with plant remains we collected the remains of insects and small mam mals. The radiocarbon date for this material is

23,300±500 (IERiZh-176). The evolutionary level of vole molars are related to the beginning of Sartanian (=late Weichselian).

2.5 430th km

Some mammoth bones of a late type are known from the deposits of the site 430th km. It is situated on the right bank of the river Ob 430 km from the river mouth, 5 km downstream from Hashgort (66°N). The height of the cliff is approximately 8-12 m. Bone remains of small mammals and insects were found in the deposits of light-grey sand with clayish gravel. This layer is located on the moraine-like deposits. The radiocarbon date for this material is 24,000±1500 (IERiZh-63). According to the morphological characteristics of the vole molars (late stages of *D. guilielmi* Sanford, 1870) the fauna of this site relates to the end of Karginian - beginning of Sartanian time (=late Weichselian).

3. PALEONTOLOGICAL DATA

3.1 Chembakchino-94 A

The data of spores-pollen analyses testify to the distribution of forest-tundra vegetation formed by pine-birch forests, dwarf birch, shrubs of the taiga zone and *Artemisia*-Chenopodiaceae complexes (determination of L.A. Pyankova). The results of a carpological study have shown that the plant assemblages recovered from the Chembakchino site contained the fruits of tree birches *Betula* sect. *Albae*, and of willows *Salix* spp., and also some needles of the spruce *Picea obovata* Ldb. Other shrubs were represented by occasional finds of dwarf birch fruits *Betula nana* L. and seeds of crowberry *Empetrum nigrum* L. Among the herbs identified the remains of marsh, aquatic and riverside species dominated. The plant macrofossil assemblages indicate that the vegetation of the region was a boggy floodplain within an area of birch-spruce forest.

On the evidence provided by the insect fauna, it is possible to conclude that during the formation of the layer studied there were plant communities similar to modern floodplain vegetation with some solitary trees. The sites lay close to the open shore with a clay substrate. This is deduced from the modern habitat distribution of the dominant beetle species (the ground beetles *Pelophila borealis* Pk., *Amara interstitialis* Chd., *A. erratica* Chd. and *Elaphrus angus-ticollis* Sahlb.). The remains of cryophilous insects (the ground beetle *Curtonotus alpinus* Pk. and the road beetles *Tachinus* sp. and *T.* cf. *arcticus* Maekl) suggest a colder climate in this region at that time in comparison to that of today.

Paleoteriological material including collared lemming *Dicrostonyx* ex gr. *renidens-simplicior* (5%), brown lemming *Lemmus sibiricus* Kerr. (18%) and tundra vole *Microtus* ex gr. *oeconomus* Pallas (77%) allows one to suggest tundra-forest environment (Borodin *et at.*, 1998).

The results of the analyses presented allow the reconstruction of a riverside ecosystem; a boggy floodplain with meadow vegetation, scrub and a fringe of birch-spruce woodland. The edge of the river was bordered by a zone of bare clay up to several meters wide and lacking vegetation. The type of ecosystem described was probably also typical of sites away from the river. The data suggest the predominance of open landscapes with boggy-meadow vegetation or open woodlands. The list of animal species present suggests that the environment cannot be equated precisely either with modern periglacial or boreal types. The species content of both the insect and the small mammal faunas suggests more rigorous climatic conditions in this region at that time than today.

3.2 Chembakchino-94 B

The carpology data from the lower part of the deposits reconstruct the floodplain spruce-birch forests (close to the type of Chembakchino-94 a) with such elements as *Pinus sylvestris* L., *Pinus sibirica* Rupr., *Betula nana* and some taiga shrubs. According to carpological analyses in the samples of sand-silt deposits the forest type of vegetation is changing by tundra type. The same tendency is proven by entomocomplexies. Among small mammals predominate *Lemmus sibiricus* and *Dicrostonyx simplicior*, about 20% of fossil remains belong to voles (*Microtus*) in which we specify *M. middendorffii* Polyakov 1881. Though all these species are considered to be ancestral to modern tundra species this fact can not exclude the forest type vegetation in the floodplain.

3.3 Nikitino

The study of carpology indicates spruce-birch (probably floodplain) forests with dwarf birch, taiga shrubs and some cryophyte species: *Dryas* sp., *Selaginella selaginoides* (L.) Link. Entomofauna is presented by arctic and subarctic species including dendrophyls *Otiorhynchus politus* Gyll., *Phtorophloeus spinulosus* Rey. associated with conifers (spruce and larch) and also cryophil steppe species - *Poecilus ravus* Lutschn. The remains of *Notaris bimaculatus* F. allow one to suggest carex communities quite close to this place. Small mammal fauna could be characterized as non-analogous with steppe (*Lagurus lagurus* Pallas 1773, *M.gregalis* Pallas 1778, *Eolagurus* sp.) and tundra (*Dicrostonys* sp., *Lemmus* sp.) elements. This component of tundra species does not exceed 5% of the remains.

3.4 Agansky Uval 1290/2

In spores-pollen spectra the high portion of trees (birch, spruce, pine), some chenopodiaceae pollen, fern and moss spores were found, whereas in plant macroremains trees were not found. The carpological data allow one to reconstruct the vegetation of a humid tundra or probably forest-tundra with dwarf birch and carex.

The examined entomocomplex is of a tundra-like type with predominating hemi- and euarctic species (*Tachinus arcticus* Maekl., *Pterostichus costatus* Men.) and with polyzonal insects and xerophyl *Morychus viridis* Kuzm et Kor. The main part of small mammal remains belongs to *M. gregalis* (76.8 %). *Dicrostonyx* cf. *henseli* Hinton, 1910 (5.03 %), *Lemmus sibiricus* (11.17 %) and *M. middendorffii* (7 %) were also found. All these species are considered to be ancestral to the modern tundra voles of West Siberia.

3.5 430th km

Spore-pollen data indicate open tundra-like landscapes with xerophyte places and spruce-birch forests in river valleys (Panova *et al.* 1988). The entomocomplex is of also tundra-like type with prevailing arctic insects. Some cryophil species of steppe landscapes were also found (*Chrysolina perforata* Gebl. and others). Small mammals are represented by *M.gregalis* (32,32%), *Dicrostonyx cf. henseli* (35.39 %), *Lemmus sibiricus* (30.27 %) and *M. middendorffii* (2.02 %) and thus are analogous to Agansky Uval-site small mammals fauna.

4. CONCLUSION

This study enable us to reconstruct the local natural environment at the moment of proboscideas burial in the West Siberian Plain. The data obtained by spore-pollen analyses indicate a zonal vegetation type, whereas other methods allow detailed landscape-climatic conditions of the investigated localities.

The analyses of Chembakchino-94 A and B sites revealed the same environments for mammoths of different evolutionary levels in the Early and Middle Pleistocene at one geographical point. It was shown, that the fossil assemblages indicate that the environment of the region was a boggy floodplain within an area of birch-spruce forest and tundra-like communities. The materials from the site Nikitino have shown that in the Late Pleistocene there was a mosaic landscape including forest, tundra and steppe elements.

Comparison of the data from Agansky Uval 1290/2 and 430th km sites (sites of the same age late Karginian - early Sartanian), revealed that there were different landscapes at different latitudes: tundra-like type including significant participation of xerophyte herb communities in northern sites (430th km) and forest-tundra in southern site (Agansky Uval 1290/2).

The results obtained to detail the environments of proboscideans of the West Siberian Plain and to compare them to the environments of other regions.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Arkhipov, S.A. 1987. *Stratigraphy of Quaternary deposits of the Tyumen oil-gas region. Specified stratigraphy basis*. Novosibirsk: IG and G Publishers (in Russian).

Borodin, A.V. 1996. Quaternary small mammal faunas from the west Siberian plain. *Acta zoologica cracoviensia*, 39: 75-81.

Borodin, A.V., Kosintsev, P.A., Zinoviev, E.V., Trofimova, S.S., Nekrasov, A.E. 1998. Palaeoecological investigations of the landscape inhabited by the early Middle Pleistocene mammoth *Archidiskodon trogontherii from* Chembakchino, Western Siberia. *Mededelingen Nederlands Instituut voor Toege-paste Geowetenschappen TNO*, 60: 343-352.

Smirnov, N.G., Bolshakov, V.N., Borodin, A.V. 1986. *Pleistocenovye grysuny cevera Zapadnoy Sibiri [Pleistocene rodents of the North of West Siberia]*. Moscow: Nauka (in Russian).

Sokolov, V.E. (ed.) 1982. *Yuribeisky mamont [The Yuribei mammoth]*. Moscow: Nauka (in Russian).

Panova, N.K., Smirnov, N.G., Bykova, G.V. 1988. Iskopayemy pomyet polyovok kak istochnikpaleoecologicheskoy informatsii [Caprolytes as a source of paleoecological information]. In A. Borodin (ed.), *Sovremennoe sostoyanie i istoriya zhivotnogo mira Zapadno-Sibirskoy nizmennosti*: 65-80. Sverdlovsk: Ural Branch of Academy of Science, USSR (in Russian).

Vereshchagin, N.K. & Mikhelson, V.M. (eds.), 1981. *Magadanskii mamontyonok [Magadan baby mammoth]*. Leningrad: Nauka (in Russian).

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Settepolesini di Bondeno (Ferrara - Eastern Po Valley): the first example of mammoth steppe in Italy

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SUMMARY: Reported here is a deposit of the eastern Po Valley (Settepolesini di Bondeno – Ferrara) containing abundant examples of fauna from the Middle Würm, Late Glacial and Holocene (Roman Age). The excavation, carried out by a hydraulic dredge in a water bed, reaches a depth of twenty metres from the field surface. The oldest faunal association portrays, for the first time in Italy, a mammoth steppe, with *Mammuthus primigenius, Coelodonta antiquitatis, Megaloceros giganteus, Bison priscus, Alces alces*, etc. The Late Glacial association provides evidence of a steppe dominated by bison. The Holocene layers, containing domestic and wild fauna, testify a prevalently wooded setting. Radiometric datings are presented here, together with environment reconstructions and hypotheses on the accumulation of fossil material.

1. INTRODUCTORY REMARKS AND FAUNAL CONTEXT

In recent years, in the province of Ferrara, extraction of sand from ancient paleoriverbeds has brought to light a deposit of considerable importance due to the presence of large fossil mammals. At Settepolesini di Bondeno (west of Ferrara), the SEI company dig to a depth of around 20 metres, in the water bed, to remove sand for building trade (Fig. 1). Amidst this sand, materials of different dimensions and type have been brought to the surface, such as gravel, blocks of clay, organic remains and bones.

The first important fossil finding dates back to 1997, when the bucket of the dredge, used to lift the material, was obstructed by what subse-

Fig.1 - Settepolesini di Bondeno sand quarry.

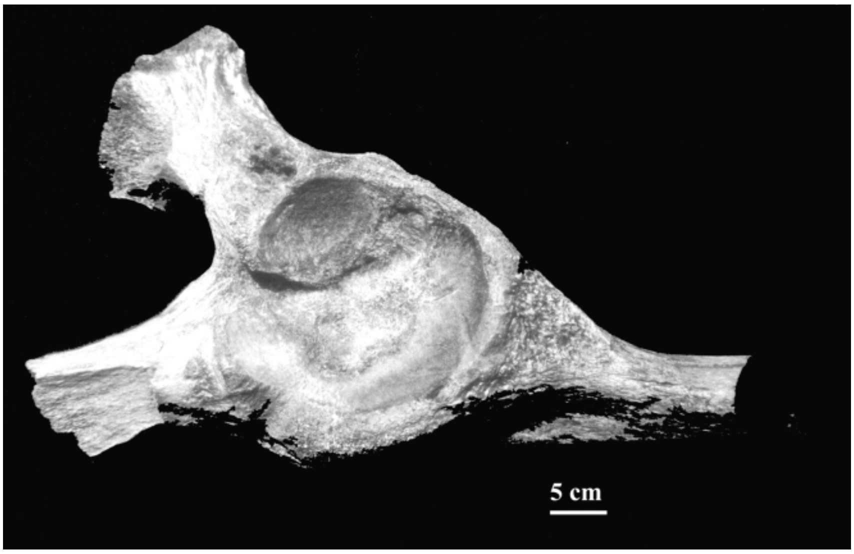

Fig.2 - *Mammuthus primigenius*: left hemipelvis.

quently proved to be the hemipelvis of a mammoth (*Mammuthus primigenius*) (Fig. 2). This was shortly followed by two fragmented skulls of Irish elk (*Megaloceros giganteus*) and the remains of steppe bison (*Bison priscus*). Realizing the significance of these findings, the Bondeno Town Council drew up an agreement with the University of Ferrara in order to study the area and reconstruct its evolution. Thanks to this agreement it is now possible to follow the excavations so that the greatest quantity of fossils are recuperated. In February 2001 the number of bones unearthed was over 360, representing *Mammuthus primigenius, Coelodonta antiquitatis, Bison priscus, Megaloceros giganteus, Alces alces, Cervus elaphus, Capreolus capreolus, Equus ferus, Castor fiber, Sus scrofa, Canis lupus, Ursus arctos*, domestic animals and some human remains.

Excavation of the water bed has led to the formation of a lake 35 hectares wide and 20 metres deep; this fact impedes the recuperation of material according to its stratigraphic sequence.

2. DATINGS

Chronological attribution of the finds was achieved by radiocarbon dating. The first samples, analyzed by the Beta Analytic laboratory (Miami, Florida), gave the following results:

Mammoth hemipelvis, fragment (Beta-128160)	34,520 –33,140 BP
Irish elk antler, fragment (Beta-128161)	32,770 –31,350 BP
Bison humerus, fragment (Beta-128159)	13,370 –13,230 BP (Cal.16664-15349 BP)
Human teeth (Beta-148560)	Cal.1880 – 1700 BP
Human scapula, fragment (Beta-133862)	Cal.1875 – 1700 BP

3. Paleoecological considerations

The species found, radiometric datings and sedimentological study of the area make it possible, for the time being, to reconstruct at least three different temporal and biological contexts.

3.1 Middle Würm (ca. 35,000 – 33,000 years ago) (Schreiner 1992)

The findings of mammoth and Irish elk, ascribed by the radiocarbon datings to this period, together with woolly rhinoceros, steppe bison and elk, denote that particular environmental context defined by Guthrie (1985, 1990) as “mammoth steppe”, documented for the first time in Italy. This was a cold steppe which extended from the Atlantic coast of Europe as far as Alaska, across Beringia (the present-day Bering Strait and Aleutine Islands). The lowering of the sea level during the glacial period had brought to light the Upper Adriatic, forming an extensive plain, and favouring faunal exchanges between the Italian peninsula and eastern Europe. Animals of varying dimensions arrived via this route and spread throughout the Po Valley: large animals like the elk, Irish elk and steppe bison, as well as smaller species such as the whistling hare (*Ochotona pusilla*), still present today in the Asian steppes, wild sicista (*Sicista betulina*) and root vole (*Microtus oeconomus*), all animals still found in the damp woods of north-eastern Europe and northern Asia.

3.2 Late Glacial (ca. 13,000 years ago)

The remains of steppe bison (*Bison priscus*) are attributed to this period. On the basis of data on the deposits of the nearby Apennine and the upper Veneto-Lombardy plain, it has been inferred that the faunal association of large mammals also comprised elk (*Alces alces*), horse (*Equus ferus*), Irish elk (*Megaloceros giganteus*), red deer (*Cervus elaphus*), and beaver (*Castor fiber*), present in the deposit but not dated.

The existence of a prevalently steppe setting with riparian wooded areas can thus be deduced. The temperature must have had higher average values than the preceding period, though it is likely that the marked drought heavily conditioned biodiversity, which is somewhat impoverished at this time throughout Italy (Bertolini *et al.* 1996).

3.3 Roman age

The sub-fossil material of the deposit is ascribed to this period; it is represented by red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), domestic animals and human remains.

The type of fauna, alongside the documentation available in literature, allows us to infer a temperate climate environment which favoured the spread of forest settings.

4. Final Considerations

It is probable that various neotectonic liftings, caused by the structural high known as the Ferrarese Ridge which crossed the area of Settepolesini di Bondeno, led to repeated deviations of the main watercourses, creating extinct branches or reduction of current.

The fresh appearance of all the fossil remains unearthed, together with the finding of whole bones without any anthropic alterations or signs of animal gnawing, permit a taphonomic hypothesis to be advanced: i.e. carcasses of drowned animals were carried downstream until they reached a shallow point, where they sank to the river-bed and decomposed, and their skeletons became covered by sediment.

The multidisciplinary commitment on the part of the University of Ferrara in the study of this area shall permit the proposed hypotheses to be verified, outlining an ever more detailed picture to be drawn of how the Po Valley setting has evolved over the last 35000 years.

5. Bibliography

Bertolini, M., Fedozzi, S., Martini, F. Sala, B. 1996. Late Glacial and Holocene climatic oscillations inferred from the variations in the micromammal associations at Grotta della Serratura (Marina di Camerota, Salerno, S Italy). *Il Quaternario,* 9 (2): 561-566.

Guthrie, R.D. 1985. Woolly arguments against the mammoth steppe – A new look at the palynilogical data. *Quarterly Review of Archaeology,* 6: 9-16.

Guthrie, R.D. 1990. Late Pleistocene faunal revolution - A new perspective on the extinction debate. In L.D. Agenbroad *et al*. (eds.), Megafauna & Man – *Discovery of America's heartland The Mammoth Site of Hot Springs, South Dakota*, inc: *S*cientific Papers, 1: 44-60. Hot Springs.

Schreiner, A. 1992. *Einfürung in die Quartärgeologie.* Stuttgart: Schweizerbart.

The World of Elephants - International Congress, Rome 2001

Reconstructions of Woolly Mammoth life history

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SUMMARY: How can we know about the life history of an extinct species, such as woolly mammoths? The Pleistocene fossil record can add considerableinformation and inference to help us reconstruct mammoth life history. So also can data from analogies with modern elephants combined with patterns seen among extant northern large-mammals. I focus here on three main categories of very non-elephant like adaptations in the areas of reproductive specialization, the dietary resources available from the unique steppic vegetation in the Pleistocene far north, and life exposed on the cold-arid open steppe. The repercussions of these three to woolly mammoth life history not only form an interesting contrast to the rest of the proboscidians, they make an interesting story of Pleistocene specializations.

1. INTRODUCTION

The ecology of an extinct species, like woolly mammoths (*Mammuthus primigenius*), is not easy to reassemble. Fortunately, several ways of approaching this are available. There is a wealth of research on general adaptive patterns in northern ungulates which can help us in this matter, especially when we combine that with details of the frozen mammoth carcasses from the far north. I will focus on three interrelated ecological aspects of woolly mammoths which provide the most contrast with more tropical elephants: (2) the likelihood of adaptive canalization of parturition (and hence conception) into a closely delimited time of the year, (3) adaptations to a dramatically different dietary resource, the low-growth steppic vegetation, (4) and several unusual adaptations to the very open and exposed environment found on steppes. I review but a few of the repercussions within these three categories.

2. REPRODUCTIVE ADAPTATIONS ON THE MAMMOTH STEPPE

In the far north there is a strikingly predictable contrast to the harshness of winter and the lush greenery of summer. This disparity selects for female ungulates which are more genetically predisposed to ovulating during optimum times of this annual cycle in order to maximize benefits of seasonal timing of that birth. Spring green-up with plants of highest nutrient quality is rather abrupt (at present late May to early June in the north). This nutrient spike (Guthrie 1984) forms a narrow window, a young born too early risks late winter storms, and yet, being born too late loses precious days of the optimum growing season.

There are many evolutionary repercussions of these dynamics which undoubtedly figured into woolly mammoth life history:

- Judging from most ungulate species in the far north, the timing of that birth season would have been targeted on the period of green-up. Pleistocene solar angles, which determine green-up, would likely have been little different than today, but there may have been less cloud cover and less snow cover (Guthrie 2001) which may have pushed the green-up to slightly earlier. As with other northern ungulates a short “canalized” birth season would have been maintained among mammoths by opposing forces of stabilizing selection.
- Assuming a rough 22 month gestation time, as in most living proboscidians, that would have dictated a rut time of sometime near late

July to early August-well past the northern summer's nutrient-caloric peak. Thus, bulls and cows (especially those without calves) would have had time to recover from winter debilitation. This late summer rut would have allowed both sexes to lay down significant fat reserves. For gravid females these future reserves would have been critical because they had to nurse young during the following winter (unlike any other northern ungulate today). Elephants nurse young for 3-5 years (Spinage 1994), and woolly mammoths may have been even more conservative in weaning due to difficulty in finding volumes of easily digestible winter forage. Fat would have been critical for these mothers of nursing young. For males, fat would have been important addition to body mass which increased force and leverage in upcoming rut battles (again, this is the way many northern ungulate males use fat today). Dominant males of several species forgo eating during this sharply defined rut peak and enter winter with reduced body fat.

- Since the mammoth cows coming into estrus would have all done so at almost the same time, there is no selective value for staggered musth year-around as in bull elephants. Rather among mammoths it would have been focused in a two-week, or so, period (the build-up of pre-rut activity may have added another week or two). Sometime in the last half of July, mammoth bulls and cows must have coalesced into mating herds in which all bulls ultimately compete directly for access to each cow as she came in to heat. As with all northern ungulates today, rut would have consisted of a wild melee of courtship, copulation, and aggression. Constraining rut in time and space results in more overtly violent confrontations, favoring dominant bulls and selecting for aggressive qualities and exaggerated weaponry. We can, in fact, see this effect among mammoth fossils-for proboscidians, mammoths have enormously exaggerated tusks in comparison to their body size.

- The special tusk size and shape of mammoths apparently relates to different fighting postures of mammoths in comparison to other proboscidians-again, driven by steppic adaptations of more frequent and violent fights resulting from canalized rut timing. Because of the mammoth's more vertical head (another steppic grazing adaptation), fights took place frontal-to-frontal, very unlike the way elephants fight. Mammoth tusks are curved, each in an opposing gaining-helix toward one another, such that they arc around, and point inward left-and-right, toward the opponent, while two bulls are engaged in a head-to-head position. From this position a strong bull can twist his head and dig the tusk tip into the opponent's vulnerable shoulder or thoracic region. Once engaged in this manner it is very difficult for the weaker one to safely uncouple and retreat, so this kind of fighting would likely be expected either between two playfully sparring adolescents or between two very serious and more equally matched prime-aged opponents. Yet, the situation where no bull would have experienced musth throughout the 11 month remainder of the year, likely firmed the bachelor bands into more permanent groups. This is an important item in reconstructing male social behavior. But there is an important point to be noted, as discussed under the next bullet.

- Trying to decipher tusk use in musth battles of mammoth bulls from the fossil record can easily lead to a mistake for several interrelated reasons: without significant predators mammoths continued to live into post-reproductive years and their tusks continue to grow, the long tusks ultimately spiral beyond a configuration useable as a dangerous weapon. So in old age, the arcing tusk-tips of an old bull approach one another and occasionally even cross. However, this dysfunctional configuration would have presented few difficulties as older animals would be reproductively senile. Musth weakens dramatically among older aged elephants and they are unable to stage a threatening combat with younger prime-aged competitors.

Yet, tusks from older mammoth bulls tend to be over-represented in our fossil sample, because of the taphonomic nature of the record (really a skewed graveyard assemblage where few prime aged bulls died) leading us to the mistaken presumption that long-tusked bulls were the functional norm. It is an interesting evolutionary case of a character using a growth pattern that results in an effective design, but once past an optimal time window this configuration inherently loses its utility. There are some similar examples of this phenomenon among living large mammals-like the horns on some individual African buffalo that ultimately hook back on themselves.

3. ADAPTATIONS TO AN UNUSUAL DIETARY RESOURCE

Woolly mammoth adaptations revolved around life on a more open cold steppe of low sward graminoids, unlike that experienced by most other proboscidians. There were several evolutionary repercussions that accompanied this dietary specialization:

- The traditional proboscidian diet is large quantities of easily available, but low quality, vegetation, taken from a very eclectic seasonal variety of species. Woolly mammoths, too, utilized a diverse diet; however, they seem to have focused primarily on thin tufts of sparsely dispersed graminoids, those were the most common plant species (Goetcheus and Birks 2001). These would have had lower biomass per bite but higher quality of nutrient content and caloric digestibility than what is eaten by elephants. Because of the small bite size, mammoths likely spent a large part of the day grazing. Also, the low plant biomass meant that woolly mammoths could quickly exhaust local ranges, particularly in winter, and thus had to be more mobile, on a seasonal scale of large migrations or a semi-nomadic life.
- Both the canalization of rut and the cold and windy winter climates seem to have selected for individual mammoths which acquired large fat reserves. Northern male ungulates today characteristically add 20% of body fat beyond lean winter values. How much fat did mammoth lay down? It is not easy to tell. There are few if any frozen mummies available from the season of peak obesity, just prior to rut (taphonomic circumstances make quality preservation of such a large animal at this warm time of year rare), but frozen mummies, preserved from other seasons, show at least significant fat reserves.
- Bone construction, especially cortex thickness is evolutionarily matched to the intensity of bone loading experienced by the animal. Bone loading of course pertains to the animal's activity, but especially to its body weight, which is to say, its weight at the heaviest time of the year. Of course with seasonal fat, mammoths body weight was probably considerably higher than an elephant of the same stature. This seasonally heavy body may be one of the forces involved in producing the significantly higher bone density of mammoths when compared to elephants (Haynes 1991).

4. THE ECOLOGY OF LIFE IN THE OPEN

Mammoth life in the vast expanses of treeless steppes was a rather novel niche for proboscidians. To prosper on the steppes probably required many evolutionary changes, including those involving social structure, mobility, dispersal rates, vagility, communication, traditional ties to landscape, and much else:

- Elephant communication in woodlands or savannas occurs mainly within long-distance infrasonic sound ranges. Elephant's large ears not only help in cooling and in visual communication, they may also help in the reception of these long distance sounds. But among woolly mammoth living in the open vistas of the Mammoth Steppe, one could argue that vision is more critical than hearing in spotting and identifying other mammoths. The selective pressures for a protruding “cup” of an external ear would be much weaker among animals in this kind of habitat. Rather, the pressures to conserve heat loss apparently favored small-sized external ear structure of mammoths, quite unlike that of any other living elephants.
- It is possible that various elements of this niche (high mobility, type of food, and climate) on the Mammoth Steppe may have selected for a more conservative life history than among proboscidians in tropical-temperate regions. For example, that the timing of life-junctures we see among today's elephants could have been slowed down among mammoths: lengthening time young males spent in the female herd, and age of female sexual

maturity. There are hints of this in the reconstructed survivorship curves using molars from fossil Alaskan mammoths. Those curves show that mortality accelerates rapidly around 20 years of age, which may help us identify the social transitions into adulthood and the higher risks which accompany these life changes.

5. REFERENCES

Goetcheus, V.G. & Birks, H.H. 2001. Full Glacial upland tundra vegetation preserved under tephra in the Beringia National Park, Seward Peninsula, Alaska. *Quaternary Science Reviews* 20: 135-147.

Guthrie, R.D. 2001. Origin and causes of the mammoth steppe: a story of cloud cover, woolly mammal tooth pits, buckles, and inside-out Beringia. *Quaternary Science Reviews* 20: 549-575.

Guthrie, R.D. 1984. Megabucks, megarams, and megabulls: gigantism is the Alaskan Pleistocene. In H.H. Genoways and M.R. Dawson (eds.), *Carnegie Museum of Natural History* 120-153. Pittsburgh.

Haynes, G. 1991. *Mammoths, Mastodonts, and Elephants-biology, behavior, and the fossil record*. Cambridge: Cambridge University Press.

Spinage, C. 1994. *Elephants.* London: Poyser Natural History.

The World of Elephants - International Congress, Rome 2001

New data on mammoth bone dwellings of Eastern Europe in the light of the new excavations of the Ginsy site (Ukraine)

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1. INTRODUCTION

Mammoth bone settlements of upper and middle Dniepr basin in eastern Europe have been the main source of information to elaborate several interpretative models, well known since a lot of years, of the hunter lifeway during late upper Palaeolithic. Nevertheless, revisiting data from old excavations and exploiting data from recent new excavations, mainly in Ginsy (Ukraine), may contribute to enlighten the knowledge of dwelling structures and their environment, giving a new consideration about existing theoretical models.

2. THE MAMMOTH BONE SETTLEMENTS IN EASTERN EUROPE

Actually, in the upper and middle Dniepr basin, many settlements, built with a large number of mammoth bones, have been discovered : Ioudinovo, Timonovka 1 2, Elisseevitchi 1, 2, Suponevo, Mizine, Kiev-Kirilivska, Dobranichivka, Ginsy (Gontsy), Mejiriche. All these sites are dated by ^{14}C around 15,000 BP.

The choice to localise the sites and the characteristics of the dwelling structures are revealing several conditions of adaptation of hunters to the cold and dry climate of the late Würm. The open-air camps are installed upon the promontory of a terrace of the slope of a river valley, most often very near a paleoravine. Such a localisation presents the advantage to protect the settlement on a promontory, nearside by paleoravines, above joining easily the plain and under giving a wide view on the river valley where animals are passing through. The choice for the localisation of the settlement is also associated with mammoth bone concentrations nearby, delivering building elements from which dwelling originality may be illustrated.

Unfortunately the knowledge of the dwelling structures of the different settlements have been only partially recorded for at least two reasons : old excavations for some sites and cryoturbation process disturbing sites located in the upper part of the Dniepr basin. The more evident dwelling structures, but always partially known, have been studied in the settlements of Ginsy, Mizine, Dobranichivka, Mejiriche Ioudinovo (Levitskii 1947; Chovkoplasse 1965; Pidoplichko 1976; Abramova et Grigorieva 1997; Iakovleva 2000; Iakovleva et Djindjian 2000). Nevertheless, the research and consequently the design of interpretative models have focused on the definition of the dwelling structure, constituted by a large mammoth bone hut and several surrounding pits (Bibikov 1967; Chovkoplasse 1965; Pidoplichko 1969,1976).

3. THE NEW EXCAVATIONS IN GINSY (UKRAINE)

The new excavations since 1992 in Ginsy, have revealed for the first time a more complex and more diversified settlement. Using progressive surface excavations of different areas of the Ginsy site, the mammoth bone dwelling structures have then been situated in relationship with the whole site, its environment and with the geomorphology of the valley slope. The Ginsy settlement is located on the promon-

Fig.1 - The large mammoth bone hut n°1 (Mizine, Ukraine). Photo Institute of Archaeology NAS Ukraine.

tory of the terrace of the valley slope of the Udaï River.

One large – 5 meter of diameter– mammoth bone dwelling is actually known, surrounded by a dozen of circular pits –1 to 2 meter of diameter and depth– mainly full of mammoth bones, reindeer bones, various artefacts and other animal bones. The dwelling structure is also surrounded with ashy areas where have been found bone charcoals, bone fragments, chipped stone artefacts, bone tools. A large mammoth bone hut surrounded by numerous pits and various activity areas around and nearby the hut is characterising a typical dwelling, as known with few variations in Mizine, Dobranichivka, Mejiriche and Ioudinovo (Fig. 1).

Fig.2 - The small mammoth bone hut in the western part of the Ginsy site. Photo L. Iakovleva & F. Djindjian.

The settlement is continuing after four meters in the west and north-west direction, with a new hut (Fig. 2), a small one-only 3 meter diameter constituted by two not twisted mammoth tusks built with several mammoth shaped bones (skull, femur). This original ovalar dwelling has been realised with the same architectural technique than the main dwelling. On the ground inside the dwelling, several rare artefacts have been discovered (reindeer antler hammer, engraved pick made with the point of a mammoth tusk, scapula with painted spots, ochre concentrations).

Around the small hut, several structures have been discovered including a hearth for ochre preparation, numerous colour concentrations with ochre sticks and blocks, an accumulation of flint micro-flakes, as if they had been thrown back from a skin used to chip tools, a dispersion of chipped flint tools, bone tools, stone artefacts, and also pits with various artefacts. Typical pits with mammoth bones and other animal bones but also a small atypical pit with chipped flint artefacts, ochre artefacts and some bone tools, have been discovered.

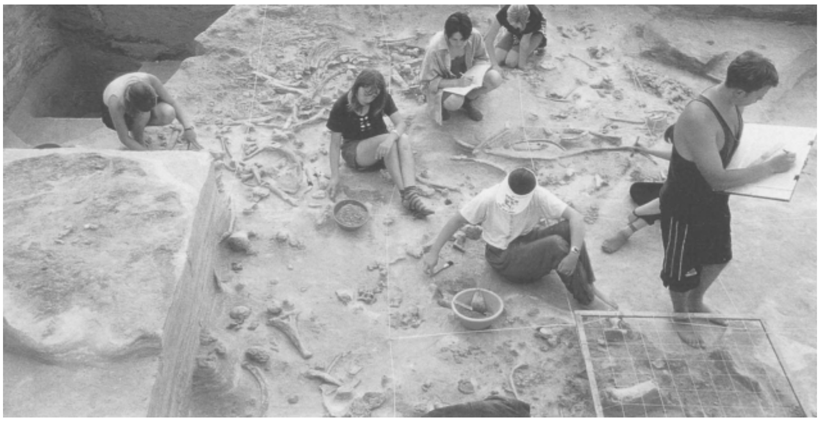

Fig.3 - The butchering area on the paleoravine slope in the eastern part of the Ginsy site. Photo L. Iakovleva & F. Djindjian.

The excavations of the contiguous area have continued in 2001. The microstratigraphy of this part of the settlement has already demonstrated existence of several rich occupation layers in the northern area of the settlement, with numerous flint and bone tools, shells and ochre concentrations.

The eastern part of the settlement has been also excavated during several years. It has been showed that the large mammoth bone hut was several meters far from the slope of a paleoravine, opening out largely towards the down of the valley slope. The wide surface of the slope of the paleoravine was covered by a bone bed of young mammoths, reindeers, bisons, small carnivores and other animals, associated with chipped flint tools and bone tools (Fig. 3). Hearths are also found in the middle of the bone bed, confirming existence of butchering areas, revealing the main components of day-to-day life inside the hunter camp. The microstratigraphy has also revealed existence of several floors (Fig. 4).

Then, data concerning mammoth bone settlements in Eastern Europe have been completed and increased with the results of the excavations of the Ginsy site. The detailed studies of the abundant data will take time to be processed by the different specialised approaches. Nevertheless, the field operations

Fig.4 - The two archaeological layers in the eastern part of the Ginsy site. Lower layer: the butchering area on the paleoravine slope; Upper layer: an occupation layer on the full up paleoravine. Photo L. Iakovleva & F. Djindjian.

are indicating the Ginsy settlement was not only one complex and diversified dwelling but also several different working areas around the dwelling in a large surrounding settlement, occupied by hunters during their different period of occupations of the site.

4. BIBLIOGRAPHY

Abramova, Z.A. & Grigorieva, G.B. 1997. *The upper Palaeolithic settlement of Ioudinovo,* vol.3. Saint Petersburg (in Russian).

Bibikov, S.N. 1967. Several aspects of palaeoclimatic modelisation during Palaeolithic. *Archéologie soviétique*: 5-22. Moscou (in Russian).

Chovkoplasse, I.G. 1965. *The settlement of Mizine*. Kiev (in Russian).

Iakovleva, L.A. 2000. *The mammoth bone settlements of Dniepr basin Archeologia*: 72-83. Kiev (in Ukrainian).

Iakovleva, L.A. & Djindjian, F. 2000. The new excavations of Gontsy site (Ukraine) in the context of the Epigravettian Campsites of the Dniepr basin. In D. West (ed.), *Proceedings of the International Conference on Mammoth Site Studies*. University of Kansas. Publications in Anthropology 22: 85-94. Lawrence.

Leviskii, I.F. 1947. *The settlement of Ginsy (1935 excavations)* vol 1: 197-248. PRU. Kiev (in Ukrainian).

Pidoplichko, I.G. 1969. *The mammoth bone settlements of Ukraine.* Kiev (in Russian).

Pidoplichko, I.G. 1976. *The Mejiriche mammoth bone dwellings.* Kiev (in Russian).

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Palaeoloxodon naumanni and its environment at the paleolithic site of Lake Nojiri, Nagano Prefecture, Central Japan

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SUMMARY: Tategahana Paleolithic Site is one of the unique sites situated at the west shore of Lake Nojiri, on the northern highlands of Nagano Prefecture, Japan. The Pleistocene lacustrine sediments named as the Nojiri-ko Formation yielded abundant fossils of extinct large animals associated with Paleolithic implements. Most of the vertebrate fossils from the Nojiri-ko Formation are *Palaeoloxodon naumanni* and *Sinomegacerous yabei* remains. Some of them are incomplete and have evidence of artificial treatment. A bone cleaver, some refitted bone flakes and chips, rib bones of *Palaeoloxodon naumanni* and stone flake tools were found in the horizon of the Middle Nojiri-ko Member I. As a result of pollen analyses, the sediments in and around Lake Nojiri were divided into nine pollen zones. The Nojiri-ko Formation dates range from OIS 4 to OIS 2.

1. EXCAVATION

The first excavation was conducted in March 1962 on the site. After that, several times of the excavations have been carried out by about ten thousand people, composed initially of non-specialists including students, teachers, laborers, farmers, and so on under the leadership of scientists. In the fourteenth excavation, in 2000, about 560 people participated and collected more than 2200 pieces of fossils and archeological remains, Molluscan fossils, insect fossils and sediment samples for microfossil study. Tategahana sites have yielded abundant fossils and the prehistoric materials, but beds containing numerous elephant fossil appear to be restricted in distribution.

More than 6700 m^2 of the main find horizon have been excavated so far.

2. GEOLOGYCAL SETTING

2.1 Stratigraphy

Lake Nojiri situated at lat. 36°49' N and long. 138°12' E and at an altitude of 645m above the sea level, with a water depth of 38.5 m and a size of ca. 4.5 km^2.

It is surrounded by four Pleistocene stratovolcanoes, namely Mt. Madarao, Mt. Iizuna, Mt. Kurohime and Mt. Myoko. Tateganaha Site lies on the west shore of the Lake Nojiri.

The Upper Pleistocene series distributed in and around Lake Nojiri is composed of lacustrine sediments with intercalation of widespread volcanic ash layers and there are divided into four formations, Biwazima-oki peat Formation, Kannoki Formation Nojiri-ko Formation and J-retu Formation from bottom to top.

The lacustrine deposits in much of the Tategahana Site can be divided into three groups which in ascending order are Lower, Middle and Upper Nojiriko Formation. Further each group is sub-divided into three units I, II, III on the basis of its lithology.

Nojiri-ko Formation consists of 100 to 500 cm of well-stratified sands and sandy silt, but contains thin pyroclastic deposits. Some the Lower Nojiri-ko Formation has ripple marks indicating shallow water condition.

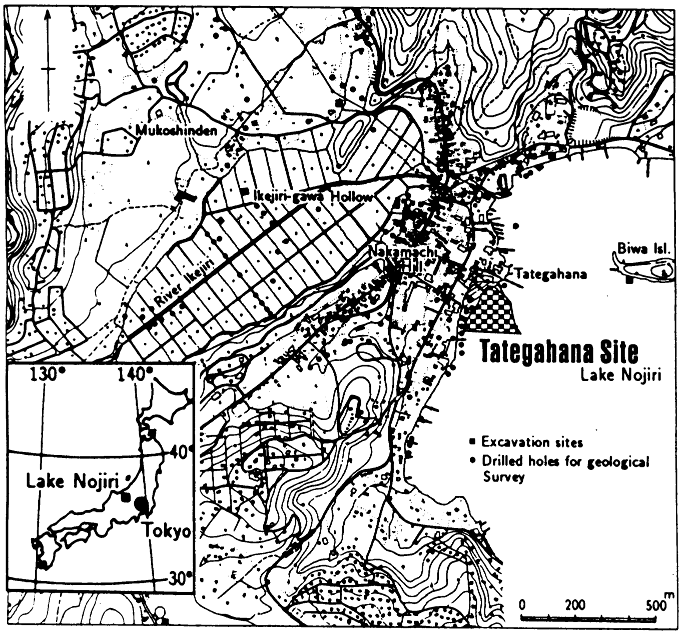


Fig.1 - Excavation sites around lake Nojiri.

2.2 Age

The age of Nojiri-ko Formation is bracketed between 11,000 and 49,000 years BP based on ^{14}C data. (Sawada *et al.* 1992, Nojiri-ko Excavation research Group 1993). The results are as follows:

J-retsu formation:
8000-11,000 BP
Upper Nojiri-ko Member II-III:
11,000-33,000 BP
Upper Nojiri-ko Member I:
33,000-39,000 BP
Middle Nojiri-ko Member:
39,000-41,000 BP
Lower Nojiri-ko Member III:
49,000-41,000 BP
Lower Nojiri-ko Member I-II:
49,000-53,000 BP
Kannoki Formations:
53,000-70,000 BP

The age of Kanaka Formation can be calculated using the sedimentation rates.

3. VERTEBRATE FOSSILS

3.1 Vertebrate taxa

The mammalian and avian fossils obtained from the Nojiri-ko Formation consisted of the following species *Palaeoloxodon naumanni, Sinomega-ceros yabei, Cervus* sp. cf. *C. nippon, Ursus arctos, Lepus* sp., *Microtus* sp., *Anser fabalis, Phalacrocorax* sp. cf. *carbo, Phasianus soemmerringii.* The majority of the vertebrate fossils are made up of two species. Fossils of *Palaeoloxodon naumanni* make 89.4% and *Sinomegaceros yabei* make 10.2% of total identified specimens.

Fossils of *Palaeoloxodon naumanni* and *Sinomegaceros yabei* have been obtained ranging from the lowermost part of the Lower Nojiri-ko Member III to the Upper Nojiri-ko Member I. Most fossils of rare species were found from the Middle Nojiri-ko Member. Fifty nine percent of the vertebrate fossils have been obtained from the upper part of the Lower Nojiri-ko Member III, although most of them were bone fragment. No articulated bones were found from the Nojiri-ko Formation. Bones from the Nojiri-ko Formation were mostly incomplete and found with some concentrations in every part of the excavated area (Ono, 2001).

3.2 The mode of occurrence of the Middle Nojiri-ko Member I

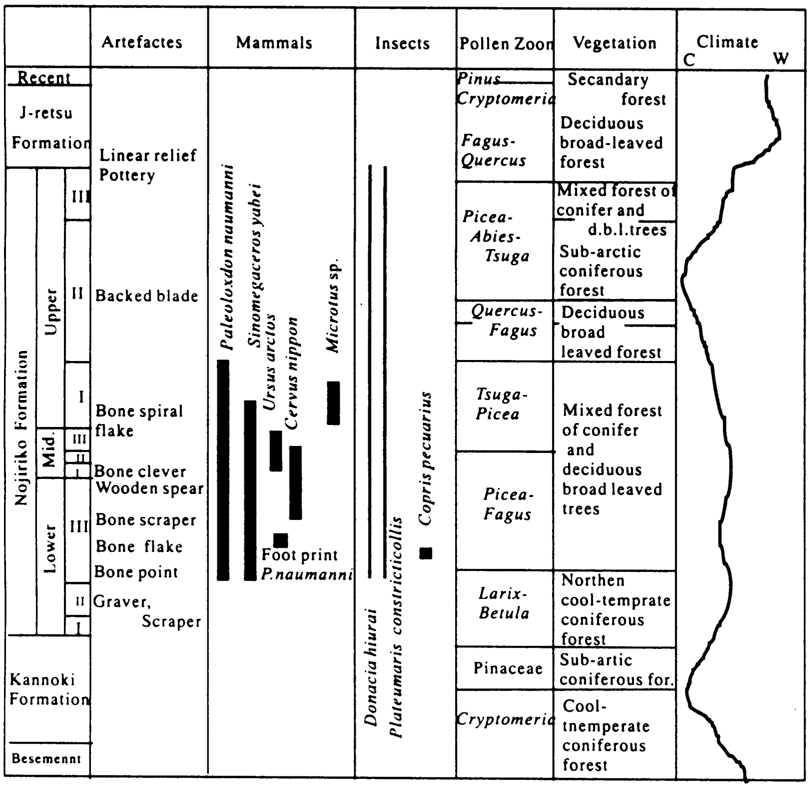
Three clusters or concentrations of bones of *Palaeoloxodon naumanni* associated with artifact are recognized in the excavated area of the Middle Nojiri-ko Member I. The skull cluster area yielded an incomplete skull, including fragments of skull, an upper M3, a radius, a wooden remain, and a boulder. The rib cluster area yielded 23 ribs (almost belong to a same individual), vertebrae, a stylohyoid, a bone cleaver, some refitted bone flakes and a bone flake core. The forelimb cluster area yielded a scapula, an ulna, carpals and metacarpals (almost belong to a same individual). It is probable that fossil assemblages of skull, ribs, and forelimbs in the range of 40 m square belong to the same individual. The arrangement of fossil assemblages is almost parallel to the recent shoreline (NE-SW) and it is presumed that the shoreline of that age coincides with the recent shoreline.

Mammalian bones and fragments should have been scattered by hydro-dynamic transport to some extent.

Lithic tool and flakes have been excavated with bone materials from Nojiri-ko Formation. In the Middle Nojiri-ko Member I, a bone cleaver, flake and chips were also found at the concentration.

Archaeological contexts suggest that the place once functioned as kill-butchering site. (Nojiri-ko Excavation Research Group, 1994; Ono, 2001).

Tab.1 - Synthetic diagram on the results by Nojiri-Ko Excavation. Adapted From Nojiri-Ko Excavation Research Group,1994.



3.3 Age profile for Palaeoloxodon naumanni

A total of 66 molars (upper 31, lower 35) were available for age determination. Laws (1966) method was applied to those fossil molars. Estimated ages were presented in African elephant years (AEY) after Haynes (1991). The result is as follows; 0-12 AEY, 4.5%; 13-24 AEY, 17%; 25-36AEY, 39%; 37-48AEY, 10.5%, 49-60 AEY, 29%. The prime-age adults pre-dominate, seniles come to the second and calves and juveniles are conspicuously rare. This resulted from time-averaged selective mortality.

3.4 Morphological features of Palaeoloxodon naumanni

The cranium of *Palaeoloxodon naumanni* has a moderately raised parieto-frontal crest and considerably inclined incisive alveoli, which are characteristic of the genus *Palaeoloxodon* (Inuzuka 1977). The stylohyoid bone has a distinct but stout process at the dorsal border of the base of the posterior ramus (Inuzuka *et al.* 1975). It is the unique character to *P. naumanni*. The tusks are considerably strong curved and twisted in males, not straight as in *P. antiquus*.

The longest tusk was 2.4 m in length.

According to Takahashi *et al.* (1991), the characteristic features of upper M3 are: dental lamella formula 18 1/2 1/2 20; width of tooth crown, mean 82.7 mm, observed range (OR) 68-93 mm, SD 7.34; enamel thickness, mean 2.61 mm, OR 1.6-3.1 mm SD 0.29; lamella frequency, mean 6.2, OR 5-8, SD 0.58. the lower M3 1/2 19; width of tooth crown, mean 77.9 mm, OR 58-96 mom's 10.37; enamel thickness, mean 2.73 mm, OR 1.8-3.5 mm SD 0.43; lamella frequency, mean 5.2, OR 4-7, SD 0.80. The molars of Nojiri-ko specimens are larger than the specimens from other localities such as Seto Inland Sea. The loxodont sinus is developed in lower molars, but not so developed in upper molars.

The shoulder height of *P. naumanni* from Lake Nojiri estimated upon femur length is 2.7 to 2.8 m. Including other localities in Japan, shoulder height is estimated to be 2.4- 2.8 m (male) and 1.9 m (female).

4. PALEOENVIRONMENT

The sediment sequences are characterized by cool-temperate element. The fossil assemblages of pollen and macroscopic remains from the Nojiri-ko Formation are composed mainly of elements of the subarctic coniferous forest tree.

The pollen found in the Nojiri-ko formation showed a great variety. Dominant conifers are *Picea, Tsuga, Abies* and *Haploxyon*, deciduous broad-leafed tree *Juglans, Betula, Alnus, Fagus, Quercus*, *Ulmus*. Seeds and cones of *Pinus koraiensis, Larix leptolepis, Tsuga diversifolia, Cornus controversa* and *Juglans sieboldiana* are also found in the Nojiri-ko formation.

The sediments distributed in and around Lake Nojiri are divided pollen stratigraphically into nine zones. (Palynological Research Group for Nojiri-ko Excavation 1993). From this Group, extremely cold climate was recognized at two horizons. The lower horizon is Kannoki Formation and corresponds to oxygen isotope stage 4.

The upper horizon is the upper part of the Upper Nojiriko Member II and the lower part of the Upper Nojiri-ko Member II, and corresponds to the oxygen isotope stage 2 The vertebrate fossil and artificial material horizon are correlative with oxygen isotope stage 3.

Molluscan fossils of the Nojiri-ko Formation are *Inversidens japanensis*, *Anodonta* sp., *Semisulcospira* sp.

Insect fossils such as *Copris pecuarius* were found from the Nojiri-ko Formation, suggesting continuous inhabitation of herbivorous animals of medium to large size.

Many foot prints of *Palaeoloxodon naumanni* and *Sinomegacerous yabei* were found from the Nojiri-ko Formation.

These fossils indicates that Tategahana site was on the shoreline of paleo-Lake Nojiri, close to the forest.

5. CONCLUSION

Data from the mode of occurrence and the age profile for *Palaeoloxodon naumanni*, as well as paleoenvironment data, indicate that Tategahana Sits is kill-butchering site. The horizon of the vertebrate fossil and artificial material was restricted to oxygen isotope stage 3.

6. REFERENCES

Haynes, G. 1991. *Mammoths, mastodonts, and elephants*: 413 pp. Cambridge: Cambridge University Press.

Inuzuka, N. 1977. On a fossil skull of *Palaeoloxodon naumanni* from Saruyama, Shimosa-machi, Chiba Prefecture, central Japan. *The Journal of the Geological Society of Japan*, 83: 523-536. [In Japanese with English abstracts]

Inuzuka, N., Hasegawa, Y. & Nogariya, H. 1975. On the stylohyoid bone of *Palaeoloxodon naumanni*. *Earth Science* (Chikyu Kagaku), 29: 36-44. [In Japanese with English abstracts]

Laws, R.M. 1966. Age criteria for the African elephant *Loxodonta a. africana*. *East Afirican Wildlife Journal*, 4: 1-37.

Nojiri-ko Excavation Research Group 1993. Choronology oh the Last Glacial deposits in and around lake Nojiri, Central Japan.Monograph 41, *The association for the geological collaboration in Japan*: 67-80. [In Japanese with English abstracts]

Nojiri-ko Excavation Research Group. 1994. The Late Quaternary environment around Lake Nojiri in Central Japan. *Proc. 29th Int'l. Geol. Conger.*, Part B: 269-277.

Ono, A. 2001. *Flaked Bone Tools*: 290 pp. Tokyo: University of Tokyo press. [in Japanese]

Palynolobical Research Group for Nojiri-ko Excavation. 1993. Fossil pollen assemblages of a drilling core from the bottom of Lake Nojiri with reference to Late Pleistocene environments. Monograph 41. *The association for the geological collaboration in Japan*: 39-52. [In Japanese with English abstracts]

Takahashi, K., Mazima, N. & Fossil Mammal Research Group for Nojiri-ko Excavation. 1991. Morphological description and its variation in the molars of the Naumann's elephant (*Palaeoloxodon naumanni* (Makiyama) from Lake Nojiri, Nagano Prefecture, Central Japan. *Journal of Fossil Research*, 24: 7-32. [In Japanese]

New data on the "Mammoth" fauna of the Laptev Shelf Land (East Siberian Arctic)

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SUMMARY. Rich fossil material of the "Mammoth" fauna was collected during Russian-German expeditions (1998-2000) in southern and southeast parts of the Laptev Sea coast. It enables us to reconstruct the Late Pleistocene and Holocene distribution of mammals in the Laptev Sea surroundings. The analysis of radiocarbon data (218 dates) gives us the possibilities to reveal different changes of population's composition and to estimate the dynamics of abundance in species in the past. This work presents the results using radiocarbon chronology for the paleoecological reconstruction.

Perennially frozen Pleistocene sediments in Arctic Siberia provide a perfect preservation of organic remains. Findings of the "Mammoth" fauna have been known for more than 200 years from the Laptev Sea surroundings. One of the earliest finding of the almost complete mammoth carcass - the "Adams' Mammoth" was found in 1799 and came from the thawing cliffs of the Bykovsky Peninsula.

During field work (1998-2000) our Russian-German expeditions in the frames of the "Laptev Sea System 2000" project investigated the Late Pleistocene and Holocene deposits on the southern and southeast coast of the Laptev Sea. The collection and study of paleontological material were the part of multidisciplinary research. More than 2000 fossil mammal bones have been collected on Bykovsky Peninsula and Bol'shoy Lyakhovsky Island. In contradiction to the other collections our one is unique by 100% registration of all bone findings. Such an approach gives the possibility to understand the composition of mammal populations which lived in these areas during the Late Pleistocene and Holocene.

The collection of mammal bones from the Bykovsky Peninsula includes more than 1000 bones (Kuzmina *et al.* 1999). In general, taxonomic composition of this collection is rather typical for "Mammoth" fauna of northeast Siberia. The woolly mammoth, horse, bison and reindeer are dominate (Fig. 1).

The collection from Bol'shoy Lyakhovsky Island also contains more than 1000 bones (Kuznetsova & Kuzmina 2000). By its size and taxonomic composition, it is comparable with the 1886 year collection by A. Bunge. The famous Russian Novosibirsk Expedition of 1886, led by A. Bunge and E. Toll, collected almost 2000 bones and discovered a great number of species of fossil mammals unknown for this part of Arctic before. Among them such mammals as saiga, a large cave "lion", woolly rhinoceros and others were described (Cherskiy 1891). However, as reconstructed from Cherskiy (1891), this collection had abnormally low percentage of mammoth bones (1.7%) and high number of hare bones (17.6%), with reindeer bones dominating the sample (39%). That looks like possible bias it is caused by the method of collecting. Our collection to be more comparable with the other known Late

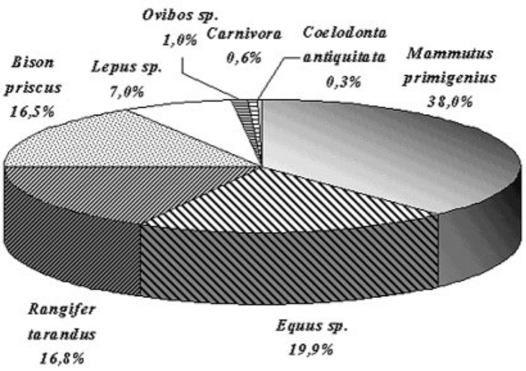

Fig.1 - Composition of mammal bones collection from Bykovsky Peninsula.

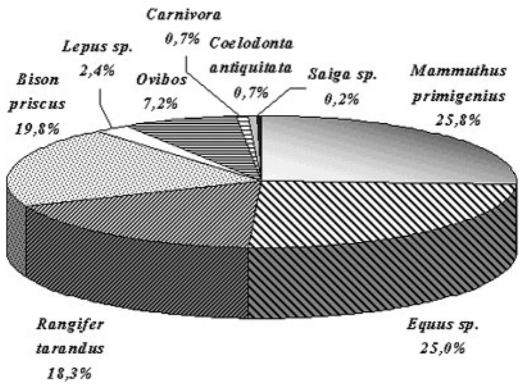

Fig.2 - Composition of mammal bones collection from Bol’shoy Lyakhovsky Island.

Pleistocene local faunas. Mammoth and horse remains dominated (25.8% and 25% respectively) followed by bison (19.8%) and reindeer (18.3%). Unusually high is the number of muskox remains (7.2%). Hare bones are only 2.4% (Fig. 2).

In addition, on the Bol'shoy Lyakhovsky Island the interesting and rather rare finds were collected: a partial skeleton of bison in natural articulation; several bones had some soft tissues preserved (ligaments) and bone marrow inside them. This skeleton was dated 34,360±400 BP. At the site of the earlier finding of partial skin and leg of mammoth (Zimovye River floodplain) we collected fragments of a mammoth’ skeleton, soft tissues and hair. For this fossil remains the age 32,500±500 BP was determined.

To reconstruct the composition of animal populations and their changes on the Laptev shelf land during the Late Pleistocene and Holocene an extensive program of 14C bone collagen dating was conducted. At the moment we have 137 dates, 78 dates of them from the Bykovsky Peninsula and 59 dates from Bol’shoy Lyakhovsky Island.

The age distribution of bones from Bykovsky Peninsula is not homogeneous (Fig. 3). The largest amount of dates belongs to the period from 36 to 26.5 ka BP. The other dates concentrate in the period 15 - 12.5 ka BP. There are also two periods with only a few dates: 44.5 - 36 ka BP and 20 - 14.7 ka BP.

The age data distribution from Bol’shoy Lyakhovsky Island differs from those mentioned above. The dates are more numerous in the period between 44 and 33 ka BP, while a reduction in the number of dates is obvious for the period 29 – 16.5 ka BP. Two periods without any woolly mammoth’ dates: 37.5 – 28 ka

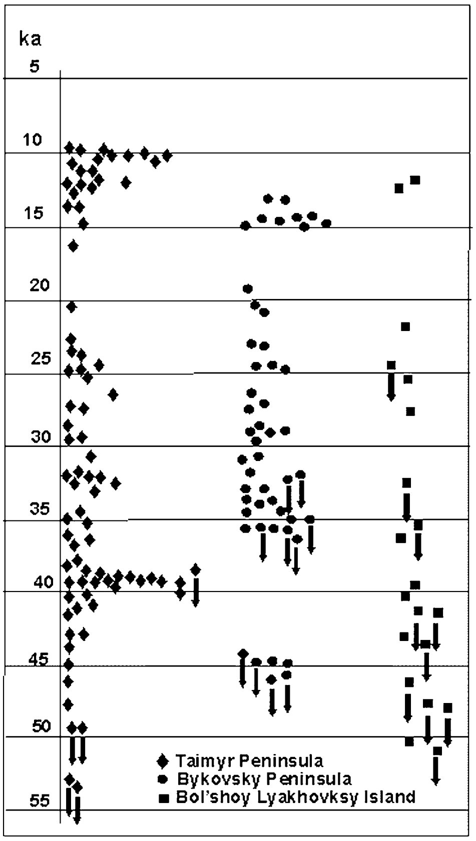

Fig.3 - Age data distribution of *Mammuthus primigenius* remains from the Laptev Sea surroundings.

BP and 22 – 12 ka BP were determined (Fig. 3).

It should be noted that the date's composition of such large collections could be strongly biased by the local geological situation, by taphonomic conditions, and other random factors. The heterogeneity of bone distribution probably reflects that different numbers of animals lived in this region. In addition we have a great database from the Taimyr Peninsula – 81 data (Sulerzhitsky 1995; Sulerzhitsky & Romanenko 1997). The paleontological collection from the Taimyr Peninsula differs from two previous collections. It contains bones collected from the different locations on this vast peninsula. In this case the local geological situation and taphonomic conditions did not so strongly influenced on the distribution of dates.

In the database from Taimyr Peninsula dates concentrate in two periods: 42 – 36 ka BP and 13.5 – 9.5 ka BP and there is one period 20 – 15 ka BP with only a few of the woolly mammoth' dates (Fig. 3).

Data of *Ovibos* sp. and *Equus* sp. are the special interest. Two very young muskox' dates from Taimyr Peninsula (2920±50 and 2700±70 BP) (Sulerzhitsky & Romanenko 1997) and two dates from Bykovsky Peninsula (3200±40 and 3180±100 BP) show a wide muskox' distribution in the Late Holocene on the southern coastal land of the Laptev Sea. Unexpected data we got on horses. In spite of a low number of horse dates (15 dates from the Bykovsky Peninsula and 11 date from Bol'shoy Lyakhovsky Island) there are two very important dates for Holocene horses from this region. One bone from the Bykovsky Peninsula is 4610±40 BP and another from the Bol'shoy Lyakhovsky Island is 2200±50 year old. This data proves that wild horses had lived during the second part of the Holocene in the coastal land of the Arctic Ocean.

CONCLUSIONS

A new professional approach to the collection of bones and an extensive program of ^{14}C bone collagen dating give the possibility to reconstruct the composition of animal populations during the Late Quaternary. Woolly mammoth bones dominate in all our collections from the Laptev Sea coast (25-40%), while horse and bison follow the next (15-25% each). The abundant database indicates a heterogeneous contribution of bones by different localities. This can depend on the geological composition of outcrops and taphonomic conditions. However, the period between 20 and 15 ka BP, seems to be a time the less favourable environmental condition for woolly mammoths in the whole southern coastal area of the Laptev Sea. Received dates by bones of muskox and horse prove that these large grazing mammals had lived during the Late Holocene on the vast territory in the East Siberian Arctic.

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REFERENCES

Cherskiy, I.D. 1891. The description of the collection of post-Tertiary mammals, collected by the New Siberian expedition of 1885-86. *Zapiski Imper. Akademii Nauk (Prilozhenie k LXV tomu)* 65, 1: 1-707 (In Russian).

Kuzmina, S., Kuznetsova, T. & Sher, A. 1999. Paleontological research on the Bykovsky Peninsula. *Reports of Polar Research. Berichte zur Polarforschung* 315: 179-187, 233-259.

Kuznetsova, T. & Kuzmina, S. 2000. Paleontological research at the southern coast of Bol’shoy Lyakhovsky Island. *Reports of Polar Research. Berichte zur Polarforschung* 354: 151-161, 223-258.

Sulerzhitsky, L.D. 1995. Characteristics of radiocarbon chronology of the woolly mammoth (*Mammuthus primigenius*) of Siberia and north of Eastern Europe. *Russian Academy of Sciences. Proceedings of the Zoological Institute St. Petersburg* 263: 163-183 (in Russian).

Sulerzhitsky, L.D. & Romanenko, F.A. 1997. Age and distribution of the “Mammoth” fauna of the Polar Region of Asia. *Earth*

The Late Pleistocene *beast solonetz* of Western Siberia: "mineral oases" in mammoth migration paths, foci of the Palaeolithic man's activity

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SUMMARY: The complex archachaeologo-palaeontologo-geological investigations allowed to reveal that the most considerable *in situ* sites of mammoth remains in northern Asia, namely of the Shestakovo and Volchya Griva sites had been the places we called the "*beast solonetz*" (localities where beasts had satisfied their mineral hunger). The mass accumulations of large mammals within the Late Pleistocene beast solonetz bear witness to the extreme palaeoecological conditions and allow considering the beast solonetz to be "mineral oases". The age profiles for the Shestakovo and Volchya Griva mammoths prove the fact that the mineral deficiency and metabolic diseases pri-marily stroke young animals, especially cubs and immature individuals. The late Pleistocene "oases" were confined to the sandy-argillaceous Cretaceous rocks, the deposits of glacier-dammed basins and spillways. The formation of the beast solonetz resulted from the favourable combination of geochemical Ca-Na-Mg landscapes and relief. A close relation was established between the beast solonetz sites, paths of mammoth migrating and travelling of Palaeolithic man groups.

1. INTRODUCTION

In Western Siberia two greatest *in situ* localities of the late Pleistocene mammalian remains in Northern Asia have been established: Shestakovo situated in the Kuznetsk Alatau submontane region and Volchya Griva – in the Barabinsk steppe (Fig. 1). Until the present time their genesis has remained uncertain. Hypotheses for the alluvial ac-cumulation, deaths of animals in drinking places and from natural catastrophes, as well as from hunting by the Pa-leolithic men, have not been supported. The peculiarity of both sites lies in the fact that more than 90% of the thou-sands of bones and teeth belong to *Mammuthus primigenius* Blum. In 1997, in studying the Shestakovo materials, the idea of the accumulation of remains within the "beast solonetz" was originally conceived (Leshchinskiy 1998). The "*beast solonetz*" is a term accepted in Russia for a ground surface site containing great amount of certain macro- and microelements. It denotes a zoogeological unit, in distinction to solonetz as a pedological nomination. Animals came to beast solonetz to eat soil and rock, to drink mineralized water from springs, in order to maintain the water-salt balance and make up a deficiency of minerals in their organism (Panichev 1990).

Thus, a new type of a mass burial of big mammaian remains has been reconstructed for Siberia and the whole Russia. The wide distribution of new types of localities has been well proved by the recent investigations in Vol-chya Griva, where the beast solonetz evolved from the soil solonetz (Leshchinskiy 2001).

2. *BEAST SOLONETZ* AS "MINERAL OASES"

The reasons for accumulation of large mammalian remains, predominantly of herbivores, within the beast so-lonetz lie in ecology, especially in the relations of animals with the abiotic environment. In the late Pleistocene the territory of Western Siberia represented the periglacial and extraglacial zones. Here, as the majority of investigators consider, the woodless spaces of tundra, forest-tundra, tundra-steppe

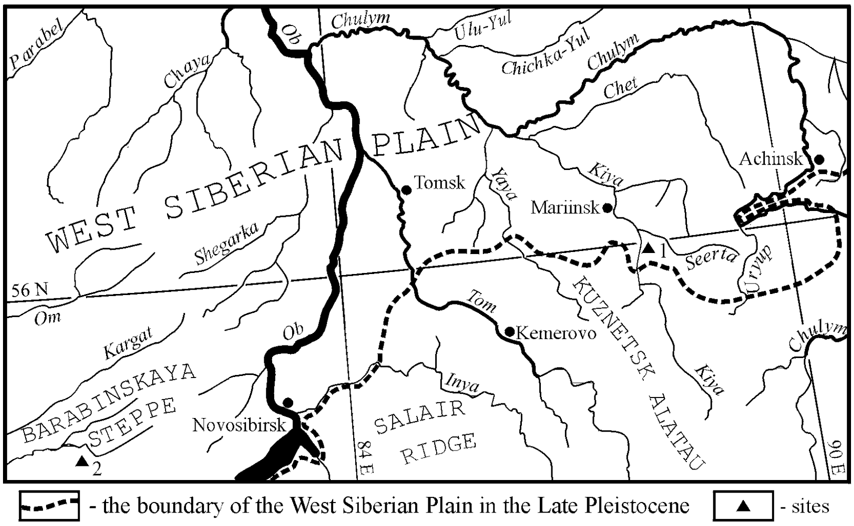

Fig.1 - Location of *beast solonetz* sites: 1 - Shestakovo, 2 - Volchya Griva.

and, less often, steppe were prevailing, complexed with the taiga districts along river valleys. The periodical wide macroclimatic fluctuations were characteristic of that time. The extreme environmental conditions were an additional peculiarity of nearly all periods. It has been established for the most part of the late Pleistocene that tundra- and steppe-land vegetation occurred, as well as the tundra-steppe fauna representatives (mammoth, woolly rhinoceros, bison, horse, saiga, polar fox, lemming and others); pseudomorphisms by desiccation fissures and cryoturbations, as well as aeolian and deluvial processes have been evidenced. Under such conditions, the geochemical landscapes of acid (H) and acid gley (H-Fe) classes most likely predominated. Besides, acid soils (podzolic, peaty-bog, sandy-loam, sandy) were widely distributed.

Nowadays, the soil types mentioned above are well developed through Western Siberia in the tundra zone, taiga-forest non-black earth areas, as well as in the arid steppe zone and, less commonly, in the forest-steppe one. In the modern view, here the large mammals are often affected by endemic diseases [fragility of bones, growth inhibition, the affection of skin, mucous coats, viscera; acobaltosis, anaemia, boric enteritis, endemic goiter, ataxia, Urov disease (Kashin-Beck disease – the endemic osteoarthrosis deformans), B_{12} hypo- and avitaminosis and other disorders]. The metabolic disorders are caused by the deficiency or excess of both macro- and microelements in the soil. In the taiga-forest zone this is, first of all, the deficiency of Ca, Mg, Na, Co (73% of cases), Cu (70%), I (80%), Mo (55%), B (50%), Zn (49%) and the excess of Sr (15%). The soils of the major steppe and forest-steppe pastures and grasslands within the West Siberia plain are now deficient in I (80%), Co (52%), Cu (40%), P and Mg at the back-ground of the excess of B (88%), Zn (76%), Sr (47%) and Mo. The salinized parts of the Kulunda steppe are par-ticularly poor in Cu and Co, 2 to12 times (> 90 %) below normal, with a consequent deficit of these elements in the vegetational fodder. This involves the severe decrease in their level in the animal organism and, as a consequence, metabolic disturbances. The maximum decrease of the Cu level in organism occurs in drought years when the levels of B and Mo in the forage are elevated, thus inhibiting the assimilation of the fodder Cu. The essential deficit in the main macronutrient elements (Ca, Mg, Na and others) affects the water-and-electrolyte balance of organism at any stage of the individual development, resulting in the rapid cachexia and death. It has been proved experimentally that the micronutrient element deficit, mainly in Cu and Co, leads to the metabolic disturbances, firstly, in young ruminants (e.g., the loss of lambs makes 10 to 50 %). The disturbances manifest themselves as gastroenteritis (the symptoms are as follows: hypotension, diarrhea, dehydration, nutritional dystrophy, etc.) and bronchopneumonia (hypoxia, locomotor ataxia, limb paresis, wool falling, etc.). As a result, the respiratory organs, intestines, liver, heart, kidneys, brain, spinal cord are affected; the disease proceeds for 5-20 days, the death rate ranges from 70 to 75% of the number of the animals getting sick (Kovalskiy 1974, Leshchinskiy 2001).

All foregoing data are presented here to prove our hypothesis for the reasons of mass accumulation of remains in the sites studied. During the late Pleistocene the landscapes impoverished in Ca, Mg, Na, Co, Cu, Zn and other elements necessary for the normal regulation of metabolism in animals were widely distributed. There is no doubt that the herbivorous animals dwelling in such landscapes experienced mineral hunger. As compared with other large mammals, the mammoth had a greater demand for the mineral nutrition of full value. It was the most massive representative of the late Pleistocene land fauna in Northern Eurasia and possessed the greatest body and carcass. The mineral deficiency is closely connected with lithophagy, i.e. using rocks, minerals and mineral water for food. The herbivorous representatives of the mammoth fauna and, especially, mammoths were undoubtedly lithophagous. This is supported by the fact that rock and mineral debris have been always found in the digestive tract and excrements of fossil animals. Thus, in the Kirgilyakh 7-8-month mammoth-calf, the content of the mineral substance (a montmorillonite-hydromica) in the large intestine terminal and in the rectum makes up 90% of the whole content mass (Panichev 1990).

The unstable climate, seasonal feeding and other circumstances caused mammoths to migrate by large distances. In unfavourable geochemical conditions, the landscapes enriched with Ca, Mg, Na, Co and other elements played a crucial role in migrating. In specific conditions, “mineral oases”, i.e. beast solonetz, were formed within such landscapes, where, besides the food enriched with macro- and micro-nutrients, the animals could eat rocks. During the periods of the utmost mineral deficit, dozens of mammoths and other herbivores were concentrating in the beast solonetz sites. The mortality of the animals and the conditions for the burial of the remains were sometimes adequate to form the bone-bearing layers.

The most widespread solonetz minerals, alongside zeolites and volcanic glass, are those of the montmorillonite group and opalites. Montmorillonite is the basic mineral substance of the montmorillonite and bentonite clays; its crystalline structure is characterised by the laminated arrangement of anions and cations (mainly, of calcium, magnesium and sodium). Each layered packing terminates in hydroxide ions capable of keeping the water molecules, thus defining the capabilities for the cation exchange and sorption. The herbivorous animals consume clay soils of such kind. This accounts for the fact that the beast solonetz sites were situated near outcrops of crusts of weathering (Panichev 1990). During the Pleistocene in the West Siberian plain, such geochemical landscapes of the Ca-Na-Mg-classes were probably formed near the outcrops of the Mesozoic aleuropelite rock mass, near the deposits of glacier-dammed basins and of runoff hollows.

As it was mentioned above, two Late Pleistocene “mineral oases” with vast mammal remains sites have been discovered, namely Shestakovo (Ca-Mg-Na-solonetz, > 125,000 m^2) and Volchya Griva (Ca-Na-solonetz, > 20,000 m^2). The Shestakovo bone-bearing layers have been dated (^{14}C) to the period from the end of the Kargin warming to the middle of the Sartan cooling (~ 26 to 18 thousand years ago) and in Volchya Griva they correspond to the second half of the Sartan (~ 15 to 10.5 thousand years ago).

2.1 Shestakovo "mineral oasis"

The Shestakovo remains site is located on the high right bank of the Kiya river, the left tributary of the Chulym river (Fig. 1), 500 m downstream from the village of Shestakovo (the Kemerovo region). The steep bank, which is being destroyed by lateral erosion, is composed of Lower Cretaceous coastal rocks (aleurolite, sand, sandstone, gritstone and clay) of the Ilek suite. Upwards, the Upper Pleistocene loess-like loam soils are deposited with disconformity. In the vicinity of the site, there are several tectonic disruptions; along one of them, a huge block ~ 25 km^2 in area has been broken off probably at the Middle/Late Pleistocene boundary. Its south-western portion is an isolated landslide ~0.5 km^2 in area. It is here that the bone-bearing and cultural layers of the Shestakovo site occurs. The sedimentogenesis, accumulation of fossil remains and artifacts were proceeding within the moisty hollow; its slopes were made up by ~ 30 m high outcrops. The hollow owes its formation to the strengthened washout of the Cretaceous rocks along the terrace joint of the landslide (Leshchinskiy 1998). The geochemical investigations of clays and sands of the Ilek suite rocks have demonstrated the high concentration of Ca, Mg, Na and other vitally important elements, this likely arising from the salinity of the Cretaceous basin. Calculations have disclosed that the macronutrient element content of the Lower Cretaceous rocks might have exceeded that of the Pleistocene soils: by Ca – 14, Mg – 4 and Na – 1.8 times. As regards the evaporate accumulation, the concentration might increase several times.

The unique combination of structure and topography have defined the existence of the beast Ca-Mg-Na-solonetz of the lythomorphic-hydromorphic type in the hollow for thousands of years. Thus, in the damper climate, there occurred a washing out of the native rocks and accumulation of deluvial deposits enriched in the scarce elements within the topographic depressions. With the climate aridization, the groundwater became primarily important in supplying the necessary elements (the super-aqueous landscape), and the permafrost was the major geochemical factor. Besides ice, the frozen rocks contained a negative-temperature water that in winter to autumn migrated to the land surface and in spring to summer backwards. The necessary elements were thereby transported from the bedrock to the active layer, and then with cryogenic mixing of the ground they arrived onto the land surface. It is precisely these sites at the bottom of the hollow that attracted the herbivores with their moisture and abundance of feeding stuff. Probably, in the same sites animals consumed the moistened argillaceous rock mass. It should be noted that beasts could consume the native rock at the hollow slopes too.

In Shestakovo the excavating works of 1975 to 1978 and 1992 to 1999 revealed more than 3000 remains belonging to 11 species of large mammals. The mammoths' bones and teeth (~18 individuals) made up no less than 90% of all palaeontological findings. Of special interest was the age profile of the mammoths decimated. Immature animals constituted a very significant rate (~ 44%), among them were: one new-born animal, three calves younger than 2 years, two individuals aged 2 to 6, one individual aged 6 to 14, besides a fragment of an embryo carcass was found. The good preservation of the bones of the immature species and the embryo suggests the presence of "mud baths" inherent in the hydromorphic solonetz soils (Leshchinskiy 1998, Derevianko *et al.* 2000).

2.2 Volchya Griva "mineral oasis"

Volchya Griva (Fig. 1) is a ridge situated in the Barabinsk steppe (near the village of Mamontovoye, Novosibirsk region). The remains site is located in the north-eastern part of the low ridge (10 m high) elongated eastward (8 km in length, up to 1 km in width). The extent of the burial is evidenced by > 5000 remains discovered, of which ~ 98 % are those of mammoths (~ 50 individuals) and the rest belong to horses (≥ 3), bisons (≥ 3) and a wolf (1). The prodigious material has been gathered just for 5 field seasons with the area excavated averaging no more than 2.5% of the whole perspective space.

At present the Barabinsk plain is a part of the West Siberian province with the sodic salt accumulation. Here the calcic, calcium-sodium and sodium-hydroxylic geochemical landscapes are distributed, and the sodic and chloride-sulphate classes of water migration prevail. The mineralization of soda waters is maximum within the uppermost water-bearing layers confined to the Pleistocene formations, thus proving the active soda formation throughout the whole Quaternary (Shvartsev 1998). In the Late Pleistocene, salinization alternated repeatedly with desalinization during the process of the landscape development in this territory. The trend for the salinization was directly connected to the evaporative concentration of chemical elements migrating upwards from ground waters onto the land surface. Besides, it was possible that salts were delivered from the territory of Central Asia and Kazakhstan together with atmospheric precipitation and dust. In the desalinisation process, the main role was played by tectonic events and humidification of climate.

The geochemical characterisation of the Volchya Griva section points to the fact that the investigated site represented the soda-sulphate solonetz throughout the Sartan cooling. Besides, the pronounced zonality throughout the site section proves the desalinization of the landscape in several levels. Of interest were the results of analyzing coprolite from the bone-bearing layer. The Ca concentration of this fossil was high (80000 g/t), but Zn content was below normal (< 30 g/t). The anomalous content of the elements in the fossil droppings suggested the animal consumption of considerable quantity of clay masses, because in vertebrates Ca constantly participates in the "skeleton" metabolism and Zn prevents the mucosa and skin lesions and osteopathy (Leshchinskiy 2001).

The age profile in the mammoths of Volchya Griva was similar to that revealed in Shestakovo. This proved that the cubs and immature species had been more susceptible to the mineral deficit and the metabolism disturbances than the adult mammoths (The rate of cubs found in Volchya Griva ranged up to 26 % and that of immature animals was ~ 42 %). The same trend is traced in recent herbivorous animals: in the endemic regions the mortality of the young species amounts to as much as 50 %, but the number of ill mature animals approximates no more than 20 % of the live-stock capita of the distinct species population (Kovalskiy 1974). Consequently, at present the majority of the recent mature animals have adapted to the unfavourable conditions. As to the rate of morbidity in the late Pleistocene, it has been much more considerable, judging from the fact that the mass burials of the Volchya Griva or Shestakovo type have no analogues in the modern landscapes of Northern Asia.

3. *BEAST SOLONETZ* AREAS AS THE FOCI OF THE PALEOLITHIC MAN'S ACTIVITY

Basing on the factual evidence of the Paleolithic encampment in the investigated territory, as well as on the paleogeographic setting in the late Pleistocene, we can state that the early man was in the closest relation to large animals such as mammoth, bison, horse and so on. The repeated findings of bones and teeth of herbivorous mammals at the encampments bear witness of the animals' dominant role in the ancient man's life. The severe conditions of life above all forced the man to be a meat-eater. The meagre plant food couldn't constantly compensate for the energy loss in the extreme conditions of the vital activity. The numerous sites of large mammals remains prove the availability of meat. Analysing the specific composition of the fossil megafauna, one can believe that horse and bison, as well as, to a lesser extent, mammoth, woolly rhinoceros, reindeer, elk and others served as the main meat source. Along with the meat, the man used the animal remains (bones, tusks, teeth, horns, skins, wool, fat, etc.) as fuel and raw material for producing tools, articles of everyday life and art. It has been discovered that not only animals hunted down were utilised, but also corpses found and carcass remains.

There is no doubt that the Late Pleistocene beast solonetz has been the foci of the early man's activity, as evidenced by the one-act mass accumulations of large mammalian remains. Firstly, cubs, weakened and ill species formed the most part of the animals coming to the beast solonetz, and hunting for them didn't involve making efforts. Secondly, in the beast solonetz there was always offal (animals died from diseases, old age, accidents or attacks of predators), which also attracted the man. Besides, the man was omnivorous and, consequently, like herbivores, he could also suffer from the mineral deficit and be lithophagous.

The activities of the man in the beast solonetz are evidenced by the cultural layers of the Paleolithic encampments superpositioned over the bone-bearing layers at the sites of Volchya Griva and Shestakovo. For example, within the Pleistocene strata at Shestakovo there are 6 cultural layers from which more than 1500 artifacts have been excavated (Derevianko *et al.* 2000). Of particular value for the man were probably the mammoth tusks: in excavating at Shestakovo, the handicrafts with notches, splitouts and tools made of tusks were found.

4. CONCLUSION

The Pleistocene/Holocene boundary has presented an impenetrable barrier in the evolution of numerous mammalian species of North Asia including *Mammuthus primigenius* Blum. The cardinal change of geochemical landscapes might have led to the disturbance in the ecological connections of biogeocenoses, and this, in its turn, has played the crucial role in the extinction of megafauna. However, the Sartan "mineral oases" established in the south of Western Siberia suggest the occurrence of refugiums in which mammoths might survive during the Holocene. The Paleolithic man has successfully overcome the fatal barrier, for the most part owing to the fact that he was an omnivore. And the changes in the environmental conditions might have been the most important factor of his cultural evolution. It is evident that the close studies on paleofaunal and paleolithic sites, especially in terms of paleoecology, must be of prior importance in studying the Quarternary.

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6. REFERENCES

Derevianko, A.P., Zenin, V.N., Leshchinskiy, S.V. & Mashchenko, E.N. 2000. Peculiarities of mammoth accumulation at Shestakovo site in West Siberia. *Archaeology, Ethnology & Anthropology of Eurasia*, 3 (3): 42-55.

Kovalskiy, V.V. 1974. *Geochemical ecology.* Moscow: Nauka (in Russian).

Leshchinskiy, S.V. 1998. Geology and paleogeography of the late paleolithic encampment Shestakovo. In A. Derevianko (ed.), *Pleistocene paleoecology and cultures of the Stone age in the North Asia and contiguous territories* (1): 209-220. Novosibirsk: Institute of Archaeology and Ethnography, S. B., Russian Academy of Sciences.

Leshchinskiy, S.V. 2001. New data on geology and genesis of the site of Volchya Griva. In A. Derevianko & G. Medvedev (eds.), *Modern Problems on Eurasian Palaeolithic*: 244-251. Novosibirsk: Institute of Archaeology and Ethnography, S. B., Russian Academy of Sciences (in Russian).

Panichev, A.M. 1990. *Lithofagy in the life of animals and human being*. Moscow: Nauka (in Russian)

Shvartsev, S.L. 1998. *Hydrogeochemistry of the hypergenesis zone*. Moscow: Nedra (in Russian).

Eastern European mammoth distribution and environments during the Middle Valdai Briansk Interstade (33,000-24,000 BP)

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SUMMARY: One of the most remarkable intervals within the Valdai Glaciation was a time of significant warming – the Briansk Interstade (33,000-24,000 yr. BP); there are abundant palaeotheriologic and palaeobotanic data, including mammoth finds, available for this interval. The principal goal of this study was an integrated analysis of the extensive database with respect to main features of mammoth environments during this Interstade. For this purpose we used mathematical as well as traditional research methods. Information on mammal and plant species composition, geology and geographical position of the sections as well as absolute and relative ages of localities has been included into databases. All data were organized in PARADOX software and then moved to ARC/VIEW GIS; the latter formed the basis for construction of electronic maps of indicator mammal and plant ranges and recognition of the principal biomes.

1. MATERIAL

1.1 Mammal data

45 Briansk mammal sites have been included into this study; most of them belong to cultural layers of Palaeolithic sites and are dated by radiocarbon. One site corresponds to molecourses of the Briansk soil, another to fluvial deposits. Mammals from five sites have been studied by one of the authors (Markova 1982; Markova *et al.* 1995). A few primary literature sources were also used, such as papers by Alexeeva (1990); Vereshchagin and Baryshnikov (1980), Guslitser and Kanivets (1965), Kalinovski (1983); Rekovets (1985), Rogachev *et al.* (1981), Tatarinov (1977) and others.

1.2 Mammoth finds

Briansk mammoth remains are widely spread over the East European Plain, from the Kama drainage basin (~60°N) in the north to the lower Dniester drainage basin (~ 48°N). They were found in the middle courses of the Dnieper and Don (~ 50 – 52°N), in the Kama basin (~ 55 –60°N) and in others regions (Fig. 1). It is possible that mammoth lived farther north, but we have not enough information for Arctic and Subarctic zones at present. No site of this age is known in the Crimea either. In the early Valdai time the range of mammoth was wider and included the Crimean Peninsula.

1.3 Paleobotanical data

During the last decades, a number of researchers, among them. Artushenko (1973), Bolikhovskaya (1995), Gurtovaya (1985), Spiridonova (1991) and others, published detailed palynological materials for the Briansk Interstade on the Russian Plain; they are supported by radiocarbon dates and by geological data.

52 plant remain localities of the Briansk time

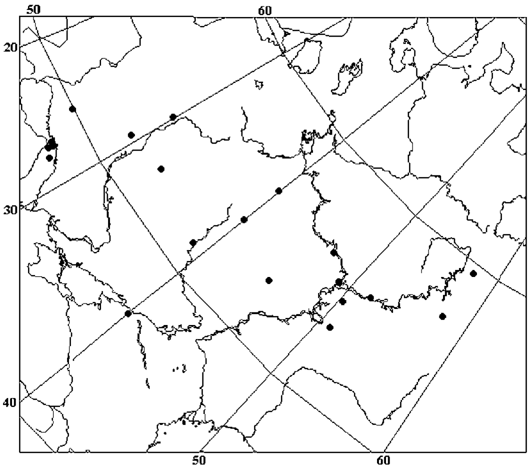

Fig.1 - The sites with *Mammuthus primigenius* remains (33 – 24 ka).

have been studied (Simakova & Kozharinov 1995). The palynological data reveal a complicated vegetation and climatic history during the Briansk Interstade.

2. METHODS OF THE ENVIRONMENT RECONSTRUCTION

The principal goal of this study was to reconstruct the mammoth environment using all available data. The integrated analysis of mammal and plant data permitted to elucidate the biogeographical situation on the Russian Plain during the Briansk Interstade warming. The lots of theriological and botanical data of the Briansk Interstade were jointly analyzed. Mathematical methods have been used for these aims (Markova *et al.* in press). At the first stage of analysis the localities were classified by mammal and plant composition. The initial theriological materials were presented as matrix of “presence - absence” of 46 genera (58 species) of mammals which have been recovered from the Briansk deposits. The squared dissimilarity matrix was calculated (using the Jakar distance) for 45 mammalian sites located in 19 geographical points. The cases in which both species were absent have been ignored during the matrix calculation. Then we analyzed this matrix for reproducing the distances, based on several underlying dimensions. The lists of mammals have been established for every class of localities. The results of this classification were analyzed both in artificial MDS dimension space, and in geographical physical space according to the coordinates (latitude, longitude). The palaeofloristic data were classified analogously, but on the basis of Euclidian distance matrix. The distances between the sites were calculated for logarithm spectrum. The distinguished classes were characterized by mean values of pollen spectra. The results of pollen analysis reflect their relative appearance (maximum value for a sample, in %) for 20 most widespread species, genera and also taxa of higher order. At the second phase the limits of biomes were defined using results of integrated analyses of these classifications, obtained for mammals and plants, and with particular reference to geographic position of all distinguished groups of sites.

3. THE RESULTS OF CLASSIFICATION OF THERIOLOGICAL AND FLORISTIC DATA

Two groups of localities with palynological materials have been distinguished as a result of classification (I, II). Each of these groups includes two sub-groups. Their ordination in the space of MDS axis could be interpreted as follows: sites of the first group (I, sub-groups 1 and 2) feature relatively high proportion of cold-loving and moisture-loving forest taxa; sites of the second group (II, sub-groups 3 and 4) include high amount of xerophytic steppe and semi-desert taxa and also some broad-leaved trees (sub-group 4).

Five groups of mammal localities have been distinguished as a result of classification. The first group includes the most isolated sites. The second and forth groups are the most remote from the first one. The third group lies closely to the forth one but very far from the second group. The fifth group occupies an intermediate position in relation to all the rest groups.

4. Principal Biomes during Briansk Interstade

The following biomes could be reconstructed from north to south based on the described above procedures (Fig. 2). Mammoth *Mammuthus primigenius* lived in most of them:

4.1 Forest-tundra

A combination of tundra and steppe plant communities with "islands" of *Pinus-Betula* open forest and with the assemblage of sub-arctic mammals (reindeer, polar fox, pied and true lemmings, and narrow-sculled voles). Mammoth was very rare here. Possibly, the biomass in the north of Eastern Europe was not sufficient for subsistence of this large herbivore.

4.2. Periglacial forest-tundra-steppe

A mosaic of plant communities, including *Betula-Pinus* and *Picea* forested "islands", meadow and halophytes steppes, and tundra vegetation patches. Mammal assemblages consisted of tundra and forest-steppe species (woolly mammoth, primitive bison, wild ox, reindeer, red deer, roe deer, horse, saiga, wolverine, polar fox, ground squirrel, common hamster, pied and true lemmings, narrow-sculled, red-backed and field voles and others).

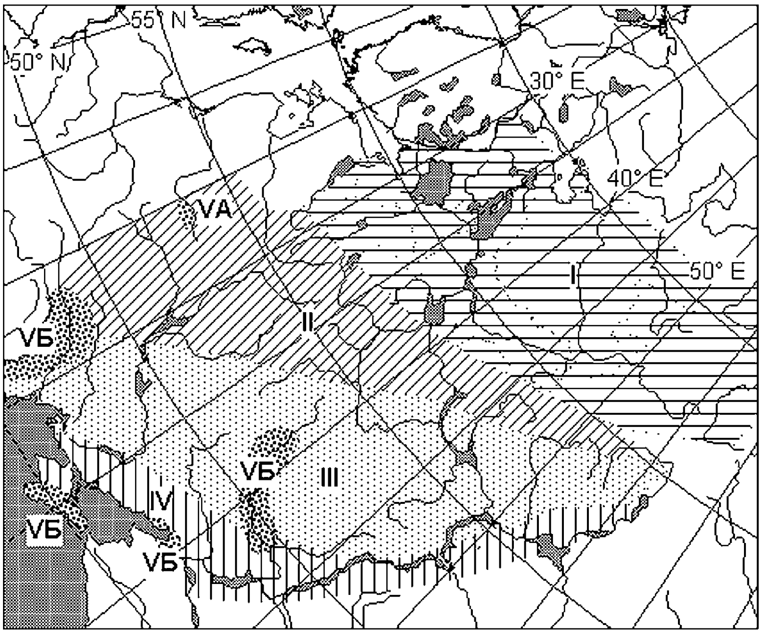

Fig.2 - Biogeographical provinces on the Russian Plain and the Crimea during the Briansk Interstade after botanical and mammal data.
I. Forest-tundra, II. Periglacial forest-tundra-steppe, III. Periglacial forest-steppe, IV. Periglacial steppe, V. Forest-steppe of plains (A), and highlands and mountains (B).

The environments with sufficient quantity of biomass favored the mammoth and other large herbivore existence in this zone.

4.3 Periglacial forest-steppe

Meadow-steppes with *Pinus-Betula* forested "islands", with scarce broadleaved trees, and with forest-steppe assemblage of mammals (woolly mammoth, woolly rhinoceros, primitive bison, wild ox, reindeer, red deer, roe deer, horse, saiga, cave carnivores, bobac marmot, ground squirrels, great jerboa, steppe lemming, narrow-sculled and field voles, and others). The environment of this biome was beneficent for *Mammuthus primigenius*. Mostly open landscapes with high biomass were favorable for mammoth, primitive bison, woolly rhinoceros and other large herbivores. The density of mammoth sites is the highest in this area. The mammal species richness is also highest among the plain regions of Eastern Europe.

4.4 Periglacial steppe

Forb steppes with the steppe mammal assemblage (woolly mammoth, woolly rhinoceros, horse, saiga, bobac marmot, ground squirrels, great jerboa, greater mole rat, northern mole-vole, steppe and yellow lemmings, and others and others including reindeer). Drier conditions of this biome determined lower biomass with respect to the previous one. This accounts for lower quantity of mammoth localities in these regions.

4.5 Plain (A) and mountain (B) forest-steppe

Betula-Pinus forests areas with few broadleaved trees and mammal assemblage of south periglacial forest-steppe (woolly mammoth, woolly rhinoceros, primitive bison, wild ox, horse, saiga, giant and red deers, reindeer, wild boar, steppe and yellow lemmings, yellow-necked mouse, field and common voles; in the Crimea the assemblage lacks mammoth, but the Pleistocene wild ass and *Microtus obscurus* are present.

5. CONCLUSIONS

The reconstructed biomes reflect specific environmental and climatic conditions of the Briansk Interstade where mammoth found favorable habitats. The analogues of modern natural zones did not exist in this time on the Russian Plain. The reconstructed landscapes reflect moderate-cool climate of this period, when the majority of northern subarctic plant and mammal species extended their ranges considerably to the south and was distributed not only in the Northern, but also in the Central Russian Plain. At the same time, steppe species penetrated farther north and west, which suggests a destruction of continuous forest zone during the Briansk Interstade. Fragments of forests persisted in topographically diversified areas with many local habitats (in highlands, mountains, and river valleys). The Briansk biomes were similar to modern ecotones in their high diversity. Earlier Guthrie, Graham, Lundelius, Semken and others have noted similar features of periglacial biota in North America.

The differences between East European biogeographical provinces were smoothed during the Briansk time: subarctic plants and mammals were present practically in every of them. Forest species, more sensitive to warmth and humidity, were not abundant on the Russian Plain. However, the periglacial forest-steppe and forest-tundra steppe were more extensive during the Briansk time than at the Late Valdai Maximum. That indicates rather temperate climate of the Briansk Interstade.

The Briansk climate undoubtedly was more severe than recent one, with lower winter temperatures and low precipitation (Frenzel 1992). Several factors had the major effect: the existence of small ice sheet in Scandinavia; a significant marine glaciation (pack ice), which affected the moisture supply to the continent; wide distribution of permafrost; and also the decrease of air masses transfer from the West to the East (van Andel & Tzedakis 1996; Velichko 1973). Such climatic conditions influenced the appearance and wide distribution of different types of periglacial vegetation and "mixed" mammal assemblages over the Russian Plain; many of them have no analogues in modern biota. Various types of open periglacial environments with great diversity of grass and bush vegetation were comfortable for large herbivores, including woolly mammoth. The palynological studies have been performed on stomach and bowels contents from the frozen mammoth bodies, found mostly in Siberia. It appeared that the animals mostly fed on the boreal and hypoarctic plants, including grasses, mosses, and also branches of trees, shrubs, and dwarf shrubs (*Betula, Alnus, Salix, Larix, Ericales*) (Ukraintseva 1992, 1996). Mammoths found the most suitable feed in wet habitats with high diversity of green grasses (Tomskaya 2000). The analysis of the mammoth distribution during the Briansk Interstade revealed the most favorable mammoth habitats. Those are: 1) periglacial forest-tundra-steppe communities situated between ~54° and 59°N (where a combination of *Betula-Pinus* and *Picea* forest “islands” with the meadow steppes, tundra associations and halophytic plant species was found); 2) periglacial forest-steppe with the meadow steppe associations and *Pinus-Betula* forest islands, with insignificant admixture of broadleaved plants. The latter plant community was located between ~ 48° and 60°N during the Briansk Interstade. Northern Subarctic regions and southern steppe areas characterized by lower biomass were not very favorable for the mammoth subsistence, because of the absence of essential diversity and quantity of forage. The lack of mammoths in the Crimea in the Briansk Interstade and the Late Valdai could be also attributed to a high activity of Paleolithic hunters in this region during the Early Valdai. Judging by the data from the Middle Paleolithic Crimean sites, mammoth was common enough there.

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7. REFERENCES

Alexeeva, L.I. 1990. *Theriofauna of Late Pleistocene of Eastern Europe*. Moscow: Nauka (In Russian).

Andel van, T.H. & Tzedakis, P.C. 1996. Palaeolithic landscapes of Europe and environs, 150,000 – 25,000 years ago: an overview. *Quaternary Science Reviews,* 15: 481-500.

Artushenko, A.T. 1973. *Forest-steppe and steppe vegetation of Ukraine in Quaternary*. Kiev: Naukova Dumka. (In Russian).

Bolikhovskaya, N.S. 1995. *Evolution of loess-sol formation of Eastern Eurasia*. Moscow: Izdatelstvo Mosskovskogo Gosudarstvennogo Universiteta. (In Russian).

Frenzel, B. 1992. Climates during Inland ice formation. In: *Atlas of paleoclimates and paleoenvironments of the Northern Hemisphere (Late Pleistocene - Holocene)*: 97-100. Budapest – Stuttgart.

Gurtovaya, E.E. 1985. The formation of Dubna horizon on the northern border of the Podol Highland. In *Palinologia chetvertichnogo perioda*: 147-158. (In Russian).

Guslitser, V.I. & Kanivets, V.I. 1965. Paleolithic sites on Pechora-River basin. In *Stratigrafia i periodizatsia paleolita Vostochnoi i Centralnoi Evropy*: 86. Moscow: Nauka (In Russian).

Kalinovskii, P.F. 1983. *Theriofauna of Late Anthropogene and Holocene of Byelorussia*. Minsk: Nauka i Tekhnika. (In Russian)

Markova, A.K. 1982. *Pleistocene rodents of Russian Plain*. Moscow: Nauka. (in Russian).

Markova, A.K., Simakova, A.N., Puzachenko, A.Yu. & Kitaev, L.M. (In press). The Russian Plain environments during Middle Valdai Briansk Interstade (33,000-24,000 yr. B.P.) by mammal and plant data. *Izvestia Rossiiskoi Akademii Nauk, Seria geograficheskaya* (In Russian).

Markova, A.K., Smirnov, N.G., Kozharinov, A.V., Kazantseva, N.E., Simakova, A.N. & Kitaev, L.M. 1995. Late Pleistocene distribution and diversity of mammals in Northern Eurasia (PALAEOFAUNA database). *Paleontologia i Evolucio*, 28-29: 5-143.

Rekovets, L.I. 1985. *Microtheriofauna of Desna-Dnieper during the Late Paleolothic*. Kiev: Naukova Dumka. (In Russian).

Rogachev, A.N., Praslov, N.D., Lazukov, G.I. *et al.* 1981. Kostenki I (site of Poliakov). 1981. In *Archeologia i paleogeographiae Russkoi Ravniny v pozdnem Paleolite*: 19-28. Moscow, Nauka (In Russian).

Simakova, A.N. & Kozharinov, A.V. 1995. Palaeoareal dynamics of the plant indicator species at the territories of the Eastern Europe during the LateValdai time. In *Late Pleistocene distribution and diversity of mammals in Northern Eurasia (PALEOFAUNA database). Paleontologia i Evolucio*, 28/29: 45-47.

Spiridonova, E.A. 1991. *The evolution of the vegetation cover of Upper Don during Late Pleistocene and Holocene*. Moscow: Nauka. (In Russian).

Tatarinov, K.A. 1977. Vertebrate fauna of Korman IV site. In *Mnogosloinaia paleoliticheskaia stoianka Korman* IV: 112-118. Moscow, Nauka (In Russian)

Tomskaya, A.I. 2000. *Mammoth forage during the Late Pleistocene of Yakutia*. Yakutsk. (In Russian).

Ukraintseva, V.V. 1992. The paleoclimate reconstructions based on palynological data. *Izvestia Rossiiskoi Akademii Nauk, Seria geograficheskaya*, 6: 90-96.

Ukraintseva, V.V. 1996. Late Pleistocene and Holocene flora of Siberia. *Botanicheskii zhurnal*, 81/12: 37-48.

Velichko, A.A. 1973. *The natural process in Pleistocene*. Moscow, Nauka. (In Russian)

Vereshchagin, N.K. & Baryshnikov, G.F. 1980. Paleoecology of the late Mammoth complex at Arctic zone of Eurasia. *Bulletin' Moskovskogo Obshchestva Ispytatelei Prirody, biol. sec.*, 85/ 2: 5-19.

The Jarkov Mammoth: 20,000-Year-Old carcass of a Siberian woolly mammoth *Mammuthus primigenius* (Blumenbach, 1799)

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SUMMARY: The Jarkov Mammoth was discovered in 1997 on the Taimyr Peninsula, Taimyr, Siberia. The remains of this 20,380 year old woolly mammoth (*Mammuthus primigenius*) were extracted from the frozen tundra under winter conditions in September/October 1999. The carcass and the surrounding sediments were taken out of the tundra using heavy equipment. The block in which the woolly mammoth remains are embedded is stored for scientific purposses in an ice cave in Khatanga, Taimyr. To get a better understanding of the environment in which the woolly mammoth was living around 20,000 years BP and about the life and death of this particular woolly mammoth the remains and the organisms collected from the sediment have been studied. The results of this multi-disciplenary research on the Jarkov Mammoth is presented.

1. HISTORY

In the summer of 1997, a family of Dolgans (a nomadic people living on the Taimyr Peninsula, Siberia, Russia) named Jarkov, discovered a 30-cm piece of a mammoth tusk protruding from the tundra, ~ 12 km south of the river Bolshaya Balakhnya (73°32' N; 105°49' E). The Jarkovs excavated the tusk, and to their surprise, they discovered the second tusk, too. Both tusks were still in anatomical position, relative to the cranium. The excavation activities of the Jarkovs damaged the cranium, maxilla, and mandible, which were also in relative anatomical position to each other. Only the tusks were removed; all bones were left in the permafrost. This mammoth, *Mammuthus primigenius* (Blumenbach, 1799) was named the Jarkov Mammoth.

A team from CERPOLEX/Mammuthus excavated the remains of the cranium in May 1998. Next to the cranium were (1) a small piece of meat, (2) skin, and (3) large portions of fur and underfur - all of which were saved. We employed a ground-penetrating radar system to see if more remains of the mammoth are present in the frozen ground. Immediately north of the cranium, anomalies in the permafrost were visible on the monitor attached to the radar. The anomalies were interpreted as potential remains of the Jarkov Mammoth carcass. We decided to extract the remains of this carcass in an unusual way: in Sept/Oct 1999, we excavated a huge block of frozen sediment that likely included the remains of the mammoth.

On October 17th, 1999, a 23-ton block of permafrost was successfully airlifted by an MI 26 helicopter from the frozen tundra of the Taimyr Peninsula. In this 13.5-m3 block of frozen sediment, remains of the Jarkov Mammoth are embedded.

2. TUSKS AND THIRD MOLARS

The Jarkov Mammoth's tusks are beautifully preserved. They are spirally twisted and reach nearly 3 m in length, indicating that they belong to an adult, male woolly mammoth, *Mammuthus primigenius* (Blumenbach, 1799).

Measurements of the right tusk include:
Maximum length (outer curve), 294 cm
Diameter, 13.5-14.5 cm
Weight, 45 kg

Measurements of the left tusk include:
Maximum length (outer curve), 298 cm
Diameter, 13.5-14.6 cm
Weight, 47 kg

The third molars in both the maxillae (M3, left and right) and mandible (m3, left and right) are preserved. The anterior parts of both molars are worn to the base of the crown. The stage of wear of the m3 is equivalent to Laws' Age Group XXV, which means that the Jarkov Mammoth had an age of approximately 47 ± 2 African Elephant Years (AEY) at the time of its death.

3. RADIOMETRIC DATES

Remains of the Jarkov Mammoth excavated by the first CERPOLEX/Mammuthus expedition (1998) have been radiometrically dated at the R. J. van de Graaff Laboratory, Utrecht University, The Netherlands, by means of the accelerator mass spectrometry method (AMS). Results of these AMS dates are as follows:

Tab.1

Laboratory number (Utrecht University)	Radiocarbon age (^{14}C yr BP)	Sample
UtC 8137	19910 +/- 130	bone
UtC 8138	20380 +/- 140	hair
UtC 8139	20390 +/- 160	skin

4. EXPEDITION 1999

In September/October 1999 about 1 m^2 of the top of the block was melted in the field, for which purpose ordinary hairdryers were used. A large portion of fur and underfur of the Jarkov Mammoth was exposed. We noted that the underfur was extremely long: up to 12 cm. We agreed that this might be the winter pelage of the mammoth.

The goal of the CERPOLEX/Mammuthus expedition in 1999 was to extract the block (with the known and potential mammoth remains and the surrounding sediment) and to transport it to an ice cave in the town of Khatanga, Taimyr, approximately 250 km south of the site of discovery. We decided to defrost the frozen block in the safety of the ice cave at a constant temperature of - 15°C, in order to collect the mammoth remains, as well as any micro- and macro-organisms trapped in the surrounding sediments.

5. REMAINS DEFROSTED TO DATE (JANUARY 2001)

In October 2000 we began defrosting operations within the Khatanga ice cave. We divided the very top of the block (the topography of which is somewhat uneven) into 20 sections, each 55 x 55 cm. The sections on the edges of the block are much smaller. Section 1 is located on the SW corner of the block; section 20 is on the NE corner. So far, defrosting by hairdryers has penetrated approximately 25 cm deep into sections 1 and 16. All sediment explored thus far has yielded fur and underfur of the mammoth, as well as plant macrofossils. Within section 1, part of one rib and, in section 16, four thoracic vertebrae of the mammoth have emerged. Three of these vertebrae were in anatomical position. None is associated with any soft tissues. It is now clear that the carcass is not intact. In the spring of 2001 the team shall return to Khatanga to continue the defrosting process.

6. INITIAL SEDIMENT ANALYSIS

Microfossils (pollen, fungal spores, algae) and macrofossils (fruits, seeds, remains of flowers, vegetative plant remains, bryophytes) were found in sediment samples from two loci studied thus far: embedded amongst the hairs of the Jarkov Mammoth, and within the lower part of the block of permafrost. Remains of beetles and Chironomids from the sediment will be studied in the near future.

The preservation of these fossils is excellent and a variety of taxa is present. The pollen spectra are dominated by Poaceae, *Artemisia* and *Papaver*. Also macrofossils of these taxa are present in our samples. The overall picture based on interpreting these fossils, is a landscape dominated by a steppe vegetation as a consequence of dry and cool climatic conditions. Moreover, pollen diagrams produced recently from lake deposits elsewhere in the Taimyr area demonstrated that vegetation during the Late Weichselian glacial maximum was typical for a steppe. This data strongly supports R. D. Guthrie’s theoretical considerations in favor of the “Mammoth Steppe” and reject the idea that mammoths were living in tundra-like vegetation.

In addition, on a local scale, mosses such as *Racomitrium lanuginosum*, *Pogonatum* cf. *P. urnigerum* and a hair-cap moss resembling *Polytrichum piliferum* are indicative of a rather dry, sandy, or stony environment, with cryogenic phenomena as well as biodisturbance as a consequence of trampling or grazing. We consider the abundant presence of spores of the dung-inhabiting fungus *Sporormiella* as clear indication of the presence of herbivores.

Among the microfossils and macroremains there are also indicators for wet conditions (e.g., the alga *Pediastrum*; the mosses *Drepanocladus aduncus*, *Calliergon giganteum*, *Rhizomnium pseudopunctatum*). The mixture of plants from wet and dry sites may indicate that the Jarkov Mammoth was covered by sediment in a depression in the landscape where local taxa were growing under wet conditions (open water and damp sites). Remains of plants from dry places may have been transported to the site by wind, but, considering their excellent preservation, transport of these plant remains by mud streams (solifluction) may have taken place. The Jarkov Mammoth may have been covered by mud after solifluction, so that the mammoth and the associated plant remains soon were under permafrost conditions.

7. ANALYSIS OF TUSKS

To learn more about the life and death of the Jarkov Mammoth, we extracted a small sample of the left tusk near its growing margin. In life, this sample would have been located deep within the tusk alveolus, spanning the entire thickness of mineralized material from the outer surface of the cementum to the soft tissue located within the tusk pulp cavity. Adjacent to the pulp cavity surface is the last dentin deposited before the animal's death; extending outward from this surface, in the sample recovered, was a 16 mm deposit of dentin laid down during the few years preceding death. We embedded this tusk sample in epoxy resin and cut it transversely producing three 5-mm thick slabs. One of these slabs was thin-sectioned for structural analysis and the other two were sampled to document changes in dentin composition during the last few years of this animal's life.

Viewed at 40x, thin sections of dentin display a clear record of hierarchically organized first-order (annual), second-order (approximately weekly), and third-order (daily) lamination, as has been described in other mammoths. The thinnest second-order incremental features tended to occur in well-marked zones, and showed the highest contrast of all the sub-annual dark-light couplets. The recurrence of these zones provided a clear visual record of first-order (annual) features. Nearly four years are recorded in this sample, with annual increments of about 4.5 mm. Comparisons suggest this represents normal tusk growth for an adult male mammoth about the time of the last glacial maximum. Death occurred at the end of the winter, just before the onset of vigorous spring growth.

Compositional profiles through the last three years of life traced isotope variation in carbonate oxygen, carbonate carbon, collagen carbon, and collagen nitrogen. The oxygen-isotope profile showed seasonally varying values that confirmed the annual increments (identified in thin section), with minimum values corresponding to mid-winter and rising values through spring and early summer. This pattern is in phase with expected variation in the composition of local precipitation, suggesting that winter precipitation, presumably snow, was ingested, but that the snow volume was so small that its melting did not dominate springtime surface-water composition. Carbon isotope values were variable, but all consistent with ingestion of C3 vegetation. Nitrogen isotope values suggest brief periods of late-winter nutritional stress about two years before death and in the final months of life, but this was probably a short-term response to seasonal food shortage. In the episode about two years before death, this stress quickly reversed with the onset of spring. The terminal episode of stress was less severe and probably not associated with the cause of death. Year-to-year contrasts in oxygen-, carbon-, and nitrogen-isotope profiles suggest a niennial (about once every two years) migration between lower latitude environments that had a less "open" vegetational structure and slightly greater moisture availability and the higher latitude mammoth steppe, where this animal finally died.

8. RADIOCARBON DATING AND PRELIMINARY ANCIENT DNA RESULTS

Forty-nine AMS dates were taken on megafaunal remains collected in 1999 and 2000. Of these, 30 are dates on mammoth remains; the rest are on muskox, bison, reindeer, canid and moose. The mammoth dates range from "infinite" ages in excess of 45,000 radiocarbon years before present (BP) to 10,270 ± 40 BP. Sixteen of the dates are in excess of 30,000 BP, which is of interest because we selected for dating only those specimens that seemed in the best condition - which we assumed would mostly be very young. The youngest date is approximately 600 years older than the most recent mammoth date form the Taimyr Peninsula (9670 ± 60 BP; (GIN 1828, uncorrected), based on a tusk from the

Nizhnyaya Taimyra River which flows out of Lake Taimyr 60 km north of Cape Sabler). The large number of well-preserved specimens of substantial age indicates how well organic remains are preserved at this latitude.

On integrating the new AMS dates with previous catalogs of Russian dates for the Taimyr Peninsula, an interesting patttern emerges. Dates are roughly evenly distributed except for three prominent gaps for which there are few or no dates: several thousands years prior to 35,000 (mid-Kargian interstadial), 18-14,000 (immediately after Last Glacial Maximum); and after 10,000 (beginning of Holocene). An unpaired t-test of the grouped data was significant, suggesting that the gaps are real. The last gap is easily explained—mammoths became extinct (except for the Wrangel population) just after 10,000 BP in Eurasia. But mammoth populations recovered after the other two gaps; they must represent periods when the Taimyr was not a favorable habitat for mammoths, or when taphonomic conditions were different. If mammoth populations were able to recover during interstadial conditions as well as after the coldest phase of the the late Weichselian/upper Zyryansk (Sartan) stadial, it seems unlikely that climate change alone can explain their complete loss from the mainland around 10,000 BP.

Five specimens collected from the 2000 expedition, including the Jarkov specimen, have yielded mtDNA. Studies are now underway on cytochrome b sequences from these specimens.

The World of Elephants - International Congress, Rome 2001

The Fishhook Mammoth: rediscovery of a Woolly Mammoth carcass by the CERPOLEX/Mammuthus Team, Taimyr Peninsula, Siberia

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SUMMARY: The Fishhook or Hook Mammoth is a 20,620 +/- 70 BP old woolly mammoth carcass. It was discovered in the estuary of the Upper Taimyra River, Taimyr Peninsula, Siberia, in 1990 and some parts of the carcass were removed in 1990 and 1992. After the site had been flooded for 8 years, it was rediscovered in 2000. In May 2001 the remains were excavated as a part of the CERPOLEX/Mammuthus program "Who or What Killed the Mammoths". The remaining parts of the carcass, including soft tissue, fur and underfur were exctracted from the frozen ground together with the surrounding sediments to learn more about the environment and the time of death of the Fishhook Mammoth.

1. FACTS

Species: *Mammuthus primigenius* (Blumenbach, 1799); woolly mammoth.

Year of Discovery: 1990, by Mr. Alexander Stolyarow, Resident, Khatanga.

Year of Rediscovery: 2000, by Mr. Sergei Pankevitch, Subdirector, Taimyr Nature Reserve; Brigade Member, CERPOLEX/Mammuthus Expedition 2000.

Location: Estuary of the Upper Taimyra River, Western Lake Taimyr, Central Taimyr Peninsula, Siberia, Russia. The Upper Taimyra River ends in the Gulf of Baikura Turku.

Coordinates: 74°08’48’’ N; 99°35’28’’ E.

Radiocarbon Date: ^{14}C accelerator mass spectrometry date = 20,620 +/- 70 BP

Gender: Male, based on (1) large cranium, (2) diameter of the tusks, and (3) size of known post-cranial skeletal elements. The cranium of the Fishhook Mammoth is extremely big, indicating an old male individual.

Size of the Fishhook Mammoth: Comparison of skeletal elements with other specimens of *Mammuthus primigenius* show that the Fishhook Mammoth stood about 260 cm at the shoulder.

2. History of the Fishhook mammoth

In 1990, Mr. Alexander Stolyarow, a citizen of Khatanga, Taimyr Peninsula, discovered a nearly complete carcass of a woolly mammoth, *Mammuthus primigenius*, in the delta of the Upper Taimyra River, near Lake Taimyr. Stolyarow removed the two wonderfully preserved tusks and, allegedly, sold them to someone in Krasnojarsk.

In 1992, a Japanese team (sponsored by Mitsubishi) visited Khatanga by invitation of Dr. Yuri Karbainov, Director of the Taimyr Nature Reserve. This team arrived in autumn when the carcass and surroundings were completely covered with snow.

The Japanese team visited the carcass site by helicopter and began to uncover parts of the frozen carcass. Although the specimen and the ground were frozen, they uncovered the skull, vertebrae, ribs, and part of a scapula. Their finds also included a lot of mammal hair, skin, and muscle.

Later in the week, the Japanese returned to the site with a “steam machine” to thaw the mammoth. Much of the carcass remained frozen in the ground, but the team removed the cranium, a humerus, a partial ulna, and a complete ulna. The team brought much of the meat and skin of this specimen to Japan, and left the bones at the museum of the Nature Reserve in Khatanga. Still, a lot of material, including some skin and muscle, was left in the permafrost at the carcass site.

When the Japanese team returned to the site the following year (1993), the entire site had been – and remained – flooded naturally by the river. This expedition included staff members of the Zoological Museum in St. Petersburg, including Dr. Mikhail V. Sablin. All activities of the team were filmed and later shown on Japanese television.

The careless and brutal way in which the Japanese team “excavated” the carcass became a scandal in academic circles in Russia. After viewing the Japanese film, the internationally renowned mammoth expert Dr. Nikolai Vereshchagin (ZIRAS) wrote an article that expressed his horror. This article was published in the major Russian newspaper Izvestie.

3. Rediscovery of the mammoth carcass

In August, 2000, Mr. Sergei Pankevitch worked for CERPOLEX/Mammuthus. He sought the mammoth carcass remains where they were first discovered in 1990. Because the area was flooded, Pankevitch searched with his fishing equipment: he was successful! On his fishhook, Pankevitch caught a muddy strand of mammoth hair. On August 27, the remains which he collected during his excursion were identified by Dick Mol. Ross MacPhee named this carcass the “Fishhook Mammoth.” This was soon shortened to the “Hook Mammoth.”

Small drilled samples of the long bones of Fishhook were taken by MacPhee and Flemming (AMNH) for DNA research and radiocarbon dating. The ^{14}C-AMS date (Beta Analytic, FL; November 2000) for the Fishhook Mammoth = 20,620 +/- 70 BP.

4. Catalogue of known parts of the Fishhook mammoth

Museum of the Nature Reserve at Khatanga (Taimyr Peninsula, Russia)

- Ulna (left), complete (both epiphyses fused); maximum length = 79 cm. (Bored samples taken by MacPhee and Flemming, AMNH).
- Humerus (right), complete (both epiphyses fused); maximum length = 89 cm. (Bored samples taken by MacPhee and Flemming, AMNH).
- Cranium, high-domed and heavily damaged (lacks tusks and molars); broken maxillae demonstrate that both M3s were broken out after specimen was unearthed. Molar alveoli indicate that small molar remains (M3) were present on both sides, indicating that the mammoth was a very old individual, older

than 55 African Elephant Years (AEY). Both M2s were lost long before to the animal's death. Maximum diameter of tusk alveoli = 14 cm; maximum width of cranium at eye sockets = 73 cm (top) and 65 cm (bottom); maximum width of posterior cranium = 73 cm. All collected skeletal remains of the Fishhook mammoth indicate that it is a very old individual.

Collection of N. Maliguina (Mammalogist, Nature Reserve, Khatanga)

- Hair, long guard hairs (multicolored)

Collection F. Kozlov (Geologist, Khatanga)

- Hair (quantity unknown)

Collection of CERPOLEX/Mammuthus L. Agenbroad (Paleontologist, NAU and Program Coordinator, CERPOLEX/Mammuthus)

- Hair, long guard hairs (brown color)

Collection of CERPOLEX/Mammuthus D. Mol (Program Coordinator, CERPOLEX/ Mammuthus)

- Hair, long guard hairs (brown color)
- Hair, long guard hairs (yellow color)
- Ulna, right proximal part with muscle attached to proximal epiphysis
- Vertebra, thoracic

Collection of CERPOLEX/Mammuthus (courtesy, S. Pankevitch, Khatanga)

- Vertebra, thoracic, with cartilage (in care of Dr. MacPhee, AMNH)
- Muscle, small strip (in care of Dr. Tikhonov, ZIRAS)

Additional mammal remains collected near the woolly mammoth by Mr. Pankevitch include:

Equus caballus (wild horse); 12 specimens
Ovibos moschatus (ice-age woolly musk ox); 1 specimen
Rangifer tarandus (reindeer); 8 specimens
Mammuthus primigenius (woolly mammoth); 45 specimens

5. The CERPOLEX/Mammuthus expedition, October 2000

In October 2000, a small expedition led by Bernard Buigues (CERPOLEX/Mammuthus) set out to study the Fishhook Mammoth. When this expedition arrived at the site, all was frozen and partly snow-covered. But, because the water level had been extremely low the previous summer (when Pankevitch rediscovered the carcass), it was relatively easy for the expedition to locate the Fishhook Mammoth. Parts of it were exposed at the surface: a portion of the vertebral column (lumbar vertebrae in anatomical position), parts of the pelvic bones, muscles, and an abundance of hair.

An expedition was planned for spring (May) 2001 by CERPOLEX/Mammuthus to extract the remains of the Fishhook Mammoth, using the same method as in the case of the Jarkov Mammoth.

6. The CERPOLEX/Mammuthus expedition, May 2001

When the CERPOLEX/Mammuthus team reached the site in May 2001, the river bank was covered with more than 200 cm of frozen snow which needed to be removed. After the site had been cleaned, approximately 75 m^2, it became clear that some of the parts of the carcass had detoriated and were scattered by the water. Nevertheless, we excavated many skeletal parts, some of which were still in anatomical order (vertebrae and ribs). The isolated parts were taken out by using jackhammers. One block of frozen sediments, including 6 vertebrae thoracales and 2 vertebrae lumbales (the last v. thoracalis is in anatomical order with the first v. lumbalis), several ribs, soft tissue, fur and underfur, was extracted and transported to an ice cave in Khatanga where it will be defrosted under controlled conditions.

7. Inventory of the remains collected by the CERPOLEX/Mammuthus expedition, May 2001

- Two fragments of the tusk socket (alveolus sin.) fitting to the cranium in the collection of the Museum of the Nature Reserve at Khatanga, Taimyr, Russia.

- Pelvic fragment including the complete acetabulum (sin.)
- Pelvic fragment including the complete acetabulum (dext.)
- Proximal half of the femur sin. (max. width at the proximal end is 34 cm. The caput femoris is completely fused with the diaphysis, which indicates a very old individual). The impression is that the complete femur was rather small.
- Complete tibia sin. (max. length 60 cm, epiphyses are fused).
- Complete fibula sin. (max. length 56 cm, epiphyses are fused). This fibula is extremely heavily built (which possibly indicates a male individual).
- Damaged fibula dext. (damage is mainly on the proximal part, the distal epiphysis is fused with the diaphysis).
- Astragalus sin., complete.
- Cuneiforme II sin., complete.
- Phalanx II (not the terminal phalanx), complete
- Scapula dext., complete (max. height 82 cm).
- Scapula sin., damaged; max. height is preserved (82 cm).
- Radius dexter, in two parts (broken) (no measurements taken because of sediments attached to the surface of the fracture). The epiphyses are fused, again indicating an very old individual. This radius is extremely heavily built (which possible indicates a male individual).
- Lunatum sin., complete (relatively small).
- 10 ribs of both sides of the animal, 6 of which are complete and 3 of which show pathological characteristics.
- Fragments of thoracic vertebrae (vertebral bodies and spines).
- One block with several parts of the Fishhook Mammoth, amongst others: 6 vertebrae thoracales and 2 vertebrae lumbales (the last vertebra thoracalis is in anatomical order with the first vertebra lumbalis), several ribs, some of which are entirely complete. The vertebrae and the ribs show soft tissues as tendons and muscles. The block is 135 cm long, 110 cm wide and 40 cm thick. Its weight is approximately 1000 kg. It was extracted from the permafrost on May 8, at 08.00 h.
- The Fishhook Mammoth block was placed in an ice cave in Khatanga on Saturday May 12th, 2001. In this ice cave also the Jarkov Mammoth block is stored.

8. RECONSTRUCTION OF THE FISHHOOK MAMMOTH

A male individual (bull), more than 55 years old at the time of the death of this animal 20620 years ago. Its height was about 260 cm at the shoulder (highest point of the back-bone) and it had an extremely large cranium (typical for an old male individual).

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Microlithic Middle Palaeolithic assemblages in Central Europe and elephant remains

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SUMMARY: Some isotopic stage 5 sites in Central Europe have yielded microlithic assemblages which are not an answer to specific raw material conditions. The settlements are often linked to water springs and the fauna assemblages are composed of one or two great herbivores. Sometimes, the elephants belong to this fauna. Their low frequency and the partial skeleton seem to indicate a scavenging in most cases. But some sites have yielded a higher frequency of these herbivores, which are often young animals. Are we dealing with anticipated specialised settlements in favourable areas for animals, dead or alive ? These great herbivores have been dismembered by very small flakes, showing the diversity of the human technical behaviour adapted to all subsistence behaviour.

1. INTRODUCTION

For 40 years ago, stage isotopic 5 sites from Central Europe have yielded microlithic assemblages with some Neanderthal remains. Some of these assemblages have been named Taubachian (Valoch 1984). These assemblages are often related to hot water springs, and the animal remains are especially those of one or two great herbivores (bovines, horses). Among the fauna, there are also remains of large mammals as elephants and rhinoceros. In some assemblages, these remains are quite numerous (for example Gánovce in Slovakia or Taubach in Germany). Most of the sites in Europe contain remains of these two great mammals in small numbers, often together (Auguste *et al.* 1998). Their presence in these Central Europe sites is, consequently, not so surprising. What is more amazing is sometimes their high frequency, and their relationship, whatever the number of remains, with the location of the site and the size of the artefacts, which are microlithic. These sites are also located in the same geographical area (small plains and basins inside Central Europe). Most of them are dated to the isotopic stage 5^e (Eemien) or to the beginning of the last glacial period (Valoch 1996).

Through their originality, these sites show evidence of a specific human behaviour. They also raise questions about specific activities near water spots, favourable areas to animal and vegetal life. Humans would have come to hunt or scavenge on dead or injured animals. Therefore, the human activities would been anticipated. The frequency of elephants, whatever the range of each species, would have a particular meaning; it would be not a matter of coincidence.

To illustrate this pattern, two sites have been chosen, providing a great deal of information about human technical behaviour. The first one is Kulna in the Czech Republic, in particular, level 11. The second one is Tata in Hungary.

2. KULNA AND TATA

The Kulna cave is located in the Moravian Karst. It was excavated by Karel Valoch, between 1961 and 1976 (Valoch 1988). Under several Micoquian layers, one level, number 11, has yielded a microlithic assemblage with an age estimated by the fauna and the microfauna remains from the isotopic stage 5 and the beginning of 4. During the deposit, a small river probably flowed through the cave.

	Kulna (level 11)	Tata
kind of location	cave a small river flowed through the cave	open air travertine
age	isotopic stage 5 and beginning of the stage 4	Brørup or end of the stage 5 U/Th between 70 000 +-2000 B.P. and 116 000 +- 1600 B.P.
fauna remains	*Cervus elaphus* *Alces alces* *Equus taubachensis* *Ursus spelaeus* *Mammuthus primigenius* *Coelodonta antiquitatis* *Rangifer tarandus*	poor assemblage *Mammuthus primigenius* *Ursus arctos*
lithic assemblages	> 10 000 artefacts	> 20 000 artefacts
raw materials	silicites-radiolarites > 50% quartz 33 % quartzite 15% some long distance stones (>50-100 km)	silicites-radiolarites 88% quartzite 11% others
technical behaviour	main debitage activity a very small shaping activity flakes : 10-30 mm long 10-15% tools	

Fig.1 - Patterns from Kulna and Tata.

Tata is an open air location, in a travertine deposit. It was excavated by L. Vertès in 1958 and 1959 (Vertès 1964). First dated from the Brørup period by the fauna remains and ^{14}C dating, new radiometric dates would place the site at the end of the last interglacial time (Schwarcz & Skoflek 1982).

The fauna remains are more numerous in Kulna than in Tata. They are dominated by cervids and horses in Kulna, associated with great mammals like elephants and rhinoceros. In Tata, the assemblage is poor, especially composed of remains of young elephants. According to the latest studies, only parts of elephant or rhinoceros skeletons compose the bone assemblages, contrary to the other species. Otherwise, in Külna, numerous bones have crushed marks, perhaps the result of the tool making.

The industry of the two assemblages is microlithic and this size is specifically chosen. The local collecting of very small pebbles from various raw materials has been established and this collecting was not imposed by the environmental patterns. Large pebbles were present around the sites, in various good quality stones. The production, which took place on the site, provided very small flakes (10-30 mm long) and some micro-choppers (10 to 30-40 mm long). The debitage system is similar in the two assemblages. It can be described as a treatment of the volume of small pebbles, with regular rules using the cortical faces and the pebble morphology (Moncel et Neruda 2000). The flakes are thick or thin; some have a back. The tools are rather rare and these are side-scrapers or points. In Kulna, the retouch is ordinary and, above all, on one face, while in Tata, the bifacial retouch is more frequent, associated to points. This kind of reduction sequence is also observed in ancient sites, as Bilzingsleben or Vertesszölös, dated older than the isotopic stage 5 (Mania *et al.* 1980; Kretzoï & Dobosi 1990). It also punctually exists in all Central and Eastern Europe during the isotopic stages 5 and 4, even if some originalities are observed, explained both by the diversity of the activities and perhaps different technical traditions.

3. SPECIALISED SETTLEMENTS?

While in the eastern part of Europe, the microlithic assemblages are linked with various kinds of sites, they are more often associated to hot water springs in Central Europe. Why should there be this type of location ? Some lucky discoveries could explain it; the excellent preservation of remains in the travertine deposits as well. However, in spite of the current state of knowledge about sites in this geographical area, because of their specific location, it is possible that these sites have been for the most part one type of settlement for human groups with a microlithic tradition. They may have provided evidence of original human settlements in favourable areas for animals and vegetation, and the presence of remains of great herbivores, as elephants and rhinoceros, would be explained by this favourable environment.

The elephant skeletons are not entire, but some of the Kulna bones show human cutting marks (Valoch 1988). They are most likely the result of a human scavenging in the surroundings. However, hunting could not be discarded. In some sites, the high density of artefacts and bones seems to indicate that men could have regularly occupied the water spring banks, why could not it be so for the hunting of great herbivores such as elephants and rhinoceros. For example, in Taubach (in Germany), the high frequency of young rhinoceros (*Dicerhorinus mercki*) in the bone assemblage and associated with *Bison priscus*, could be a proof of a easy prey hunting (*cf.* Bratlund Bodil study in Jahrbuch RGZM 46, 1999), as we believe occurred in some sites of western Europe (Auguste *et al.* 1998). It would be the same case in Gávnoce with both *Elephas antiquus* and *Dicerhorinus mercki*. While Kulna level 11 yields some elephant remains, the Tata assemblage yields young elephant remains as a main component. But they are unfortunately too few to provide a discussion on the evidence of hunting or scavenging.

The technical analysis shows a great technical community among the sites and it is difficult to imagine that such an original kind of raw material use is only present in these settlements. If it was the case, why did they make such small flakes ?

If it seems to be very difficult to admit that the small tools which have been preserved, have been used for hunting, it is conceivable, on the other hand, to believe that they could have been used for much of the animal processing. These flakes, held in the hand, could have been used alone. The palaeontological studies give evidence of a different type of hand prehension for the Neanderthal man. The flakes could also have been used alone or grouped on a wooden blank. They also could have been remains of the preparation of wooden tools, frequent raw material in a forest environment.

At least, the assemblages show that elephants are associated with humans in Central Europe. Their frequent presence in assemblages from water spring locations is not only due to our good fortune. It is most likely evidence of deliberate behaviour on the part of some European Neanderthal groups who knew the extraordinary richness of life living around the natural springs.

4. REFERENCES

Auguste, P., Moncel, M-H. & Patou-Mathis, M. 1998. Chasse ou “charognage”: acquisition et traitement des Rhinocéros au Paléolithique moyen en Europe Occidentale, Colloque d’Antibes, Economie préhistorique: les comportements de subsistance au Paléolithique, 23-25 octobre 1997, *APDCA*, CNRS: 133-153.

Kretzoi, M. & Dobosi, V. 1990. *Vertesszölös. Man, site and culture*, Budapest.

Lozek, V. 1954. Die Weichtiere der Pleistozänen Travertine in Gánovce. *Anthropozoikum*, IV: 104-105.

Mania, D., Toepfer, V. & Vlcek, E. 1980. Bilzingsleben I. Homo erectus, seine Kultur und seine Umwelt, Veröffentlichungen Landesmuseum, Berlin, 32.

Moncel, M-H. & Svoboda, J. 1998. L'industrie lithique des niveaux éemiens de Predmosti II (Brno, République Tchèque). Fouilles de 1989-1992. Etude des méthodes d'exploitation, des objectifs du débitage et de l'outillage d'un assemblage microlithique du Paléolithique moyen. *Préhistoire Européenne*, volume 12: 11-48.

Moncel, M-H. & Neruda, P. 2000. The Külna level 11: Some Observation on the Debitage Rules and Aims. The originality of a Middle Palaeolithic microlithic assemblage (Kulna cave, Czech Republic). *Anthropologie, Brno*, XXXVIII/2: 217-245.

Prosek, F. 1958. Die archäologische Funde in der Travertinkuppe Hradok. Zusammenfassender Bericht über den Fundort Gánovce und die Reste des Neandertales in der Zips (CSR), *MS. Archeol. ust.csav*, Praha.

Schäfer, D. 1981. Taubach. Zur Merkmanalyse von feuersteinartefakten der mittelpaläolithischen Travertin-fundstelle sowie zu ihrem Verältuis zu technologie anderer alt-und mittelpaläolithischer Fundplätze, *Ethn. Archaol. Zeitschrift*, 22: 369-396.

Schwarcz, H.P. & Skoflek, I. 1982. New dates for the Tata Hungary archaeological site, *Nature*, 295: 590-591.

Valoch, K. 1988. *Die Erforschung der Kulna-Höhle 1961-1976*, Anthropos, Brno, Band 24.

Valoch, K. 1984. Le Taubachien, sa géochronologie, paléoclimatologie et paleoethnologie. *L'Anthropologie*, 88, 2: 193-208. Paris.

Valoch, K. 1996. Le Paléolithique en Tchéquie et en Slovaquie, "Préhistoire d'Europe". Grenoble, 3: 205.

Vertès, L. *et al.* 1964. *Tata. Eine Mittelpaläolithische Travertin-Siedlung in Ungarn*, Budapest 141, Akademia Kiado, series Nova, XLIII, 284.

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Seasonal hunting of mammoth in the Ach-Valley of the Swabian Jura

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SUMMARY: This poster discusses the seasonality of mammoth hunting in the Ach Valley of the Swabian Jura during the Early Upper Palaeolithic. The aging of the infantile mammoth remains of two cave sites, the Geissenklösterle and the Hohle Fels, are discussed. Some of the infant mammoth bones bear cut marks suggesting an anthropogenic origin. In all three main occupation layers of the Geissenklösterle (AH I: Gravettian, AH II: Upper Aurignacian, AH III: Lower Aurignacian) as well as in the Gravettian layers of the Hohle Fels infantile mammoth remains were found, indicating that mammoth hunting took place repeatedly in spring and early summer.

1. INTRODUCTION

The region of the Ach Valley has a long history of research conducted by the Institute of Prehistory and Archaeology of the Middle Ages at the University of Tübingen. During the last decades, this research focused on the Geissenklösterle and Hohle Fels sites. Other important cave sites in the Ach Valley are Grosse Grotte (Wagner 1983, Weinstock 1999), the Brillenhöhle (Riek 1973, Boessneck & v.d. Driesch 1973) and Sirgenstein (Schmidt 1912).

The analysis of the Geissenklösterle fauna was recently completed (Münzel *et al.* 1994, 1997, 1999) and an analysis of the Hohle Fels fauna is currently being undertaken (for a detailed archaeological introduction of the two sites see my contribution ‘The Production of Upper Palaeolithic Mammoth Bone Artifacts from Southwestern Germany’)

2. MATERIAL

2.1 The infant mammoth remains of the Geissenklösterle

In the Gravettian layer only a few pieces of infant material were found including a fragment of a M2-lamina, three carpal and tarsal bones and a first phalanx of the middle digit. All of these remains are comparable in size to the main group in the AH II (see below), only the first phalanx is bigger, probably belonging to an older infant.

The majority of the infantile mammoth remains was found in the Upper Aurignacian layer (AH II). The abundance of mammoth calf remains in this layer does not reflect specialisation on calf hunting during the Upper Aurignacian. Remains of young mammoths are present in all three archaeological levels. The better preservation of all faunal remains in AH II is probably related to the presence of the big hearth area with burnt bone ashes.

In AH II there are: one right and two left upper jaws with M1 (dP2) and M2 (dP3) (Fig. 1), several large skull fragments including parietal, temporal, frontal and occipital, and many small unidentified skull fragments (three of them with cut marks). Additionally two right milk tusks (Fig. 2), a distal diaphysis of an ulna without epiphysis (with cut marks) and several carpals, tarsals and phalanxes are present.

In the Lower Aurignacian horizon, AH III, only a pair of milk tusks (Fig. 3) were found and some tarsal or carpal bones.

Cut marks on some of the bones clearly show that these mammoth infants were hunted by man and not by carnivores.

Fig.1 - Upper left jaw, M1 in place, M2 erupting. Geissenklösterle AH II.

Fig.2 - Milk tusks, open root (left), broken root (right), Geissenklösterle AH II.

Fig.3 - Pair of milk tusks with slightly resorbed or reduced roots, Geissenklösterle AH III.

2.2 The infant mammoth remains of the Hohle Fels

Several remains of mammoth infants were also found in the Gravettian layer of the Hohle Fels. They include a talus, a calcaneus, one complete and one fragmented finger bone with a cut mark. The talus and the calcaneus are smaller than the comparable elements of the AH II in the Geissenklösterle, indicating a younger age.

3. RESULTS

3.1 Aging of the calves

The exact age at death is still difficult to evaluate. The majority of the remains in the AH II, especially the postcranial elements, but also the skull fragments and the upper jaws, are comparable in body size with a $^3/_4$ year old (Laws 1966) African elephant, which was used as reference skeleton. This indicates that the majority of the Geissenklösterle mammoth infants belong to a homogenous age group. The first two molars of the African calf show tooth wear, while the teeth in the upper jaws from Geissenklösterle are still erupting and come from younger animals than the African reference skeleton.

The three upper jaws of the Geissenklösterle contain the first and the second molars. In two of the jaws the first molar is in place and in one it is not fully above the alveolar border. None of the teeth show tooth wear. The second molars are erupting, the lamellae are connected at the base, but not connected with cementum.

Recently Kusmina (1999) published on the ages of several baby mammoth mummies from the Siberian permafrost. The description of the teeth development of a 2-4 week old mammoth from Sjewsk and of a 4 week old from Yamal fits the best to the tooth eruption stage of the upper jaws from the AH II of the Geissenklösterle. That means, the main group of the infant mammoths were probably ca. 1 month old at death.

But slightly younger as well as slightly older calves are also represented in the teeth material by two laminae of a M2, smaller than the M2‘s in the upper jaws. Also two laminae of the M3, that do not fit into the M3-alveole of the upper jaws, evidently belong to older individuals.

The milk tusks in AH II are of two mammoth infants of different age. One tusk is still open at the tip of the root, while the root of the other one is broken off, but must have been complete.

The pair of milk tusks found in the AH III, already shows reduction at the tip of the roots, caused by the permanent tusk, which was already protruding. It is not clear, which stage of milk tusk development belongs to one of the above mentioned upper jaws from the, main age group, because they were found separately. Following the description of Kusmina (1999) the milk tusk with the open root should belong to a 2 week old mammoth and the pair of milk tusks with the resorbed roots to a 2-4 week old animal. But Lazarew (1994) ages a mammoth infant from the Indigirka river in Jakutien, which shows resorbtion at the milk tusk roots, with 2 months. So the exact aging of the milk tusks remains uncertain.

3.2 Calving season of mammoth and annual cycle

Considering the vegetational conditions during the Pleistocene, mammoth most probably had a calving season in spring like other grazing and browsing species in subarctic climate. Mammoth infants must have arrived synchronously in the early spring to maximise their growth during the first summer and survive the following winter (Guthrie 1990). Therefore we can suggest a calving season for mammoth in spring.

The seasonal classification adopted here is that of a wood steppe zone, a continental region as it is described in the Ukraine by Walter & Breckle (1983):

- Spring is from the end of April till the end of May: deciduous cover of the trees is completed;
- Early summer runs from the beginning of June until the middle or end of June: relatively wet, the herbaceous layer blooms;
- Summer goes from middle or end of June

until the end of August: herbaceous cover is dried out;

- Late Summer is from end of July til the end of August: slight phase of precipitation, new green puts forth;
- Autumn goes from end August until mid-October: fall of the leaves;
- Winter is from end-October until the middle or end of April and starts with the first snowfall.

Following Guthrie (1990) and Walter & Breckle (1983), the month of May can be viewed as the major calving season for mammoth.

3.3 Hunting season for mammoth and season of occupation

Having evidence for slightly younger as well as slightly older infants between the remains of the main age group of mammoth infants, there are two possible explanations. Either they were hunted during a longer period or calves of different ages are represented in a mammoth herd like in modern elephant herds (Haynes 1991). The first explanation is more likely, considering the postulated synchrony of the calving season. In this case the hunting of mammoth can be placed in the spring with a range in age of about one month documented in the Ach Valley assemblages (Fig. 4).

4. CONCLUSIONS

Until now, there was a general consensus that the valleys of the Swabian Alb only had enough nutritional supply for grazers during the warm season of the year and therefore the occupation of the caves also occurred during the warm and temperate seasons of the year (Hahn 1983).

The new archaeozoological results from Geissenklösterle and Hohle Fels show that horse was repeatedly hunted during winter (fetal horse bones) and mammoth in the spring. Additionally cave bear was exploited during the winter time until spring, during their hibernation. Cave bear hunting is evidenced by the vertebrae with a projectile point found in the Hohle Fels, and exploitation by cut and blow marks on bones, which represent all stages of the butchering process as it is known from other game (Münzel *et al.*, in press).

In other words, the mammoth hunting in

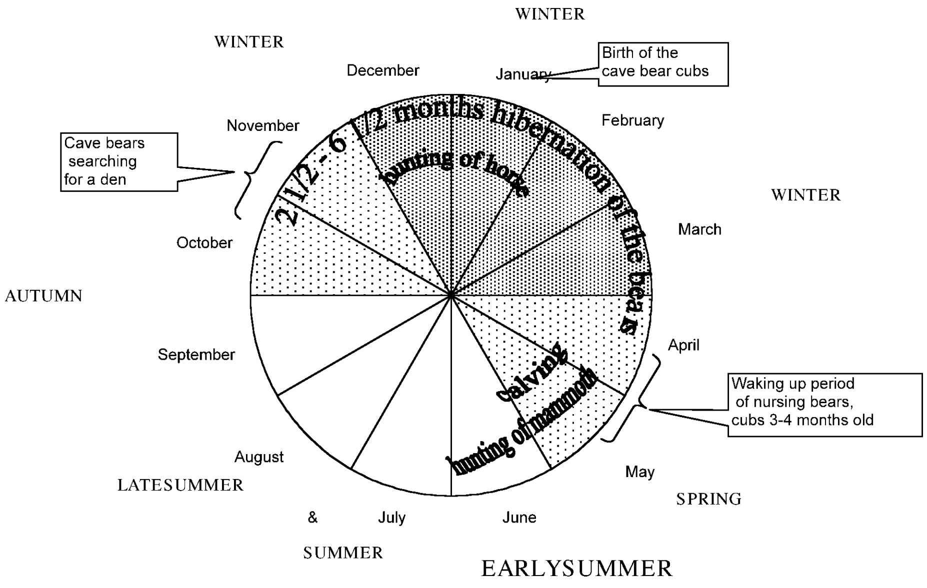

Fig.4 - The hunting season of mammoth and horse and the annual cycle including the activities of cave bear in the Ach Valley.

spring reflects the end of a winter occupation in the caves of the Ach Valley. A summer and autumn hunt of other game cannot be excluded, but the archaeological best recognisable season of occupation in the Ach Valley is winter and spring.

5. REFERENCES

Boessneck, J. & von den Driesch, A. 1973. Die jungpleistozänen Tierknochenfunde aus der Brillenhöhle. Riek, G. Das Paläo-lithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 4/II. Stuttgart: Müller & Gräff.

Guthrie, D. 1990. *Frozen Fauna of the Mammoth Steppe. The Story of Blue Babe.* London & Chicago: University of Chicago Press.

Hahn, J. 1983. Eiszeitliche Jäger zwischen 35000 und 15000 Jahren vor heute. In Müller-Beck, H. (ed.), Urgeschichte in Baden-Württemberg: 273-330. Stuttgart: Theiss.

Haynes, G. 1991. *Mammoths, Mastodonts & Elephants. Biology, Behavior and the Fossil Record*. Cambridge: Cambridge University Press.

Kusmina, I.E. (ed.) 1999. Deljonyschy mamonla [Die Kinder des Mammuts] Mammuthus primigenius (Blumenbach, 1799). *Arbeiten des Zoologischen Instituts* 275. St. Petersburg: Russische Akademie der Wissenschaften.

Laws, R.M. 1966. Age Criteria for the African Elephant. *East African Wildlife Journal* IV: 1-37.

Lazarew, P. 1994. Überreste eines Mammutkalbes vom Indigirka-Fluß in Jakutien (Republik Sakha). Deutsch von J. Besso-lit-Zina & R. Kinzelbach. *Informationen aus dem Hessischen Landesmuseum in Darmstadt,* 2/94: 25-28.

Münzel, S. C. 1997. Seasonal Activities of Human and Non-human Inhabitants of the Geissenklösterle-Cave near Blaubeuren, Alb-Danube District. *Anthropozoologica*, 25/26: 355-361.

Münzel, S.C. 1999. DFG-Abschlußbericht zur Großsäugerfauna im Geissenklösterle. *Unpubl. manuscript.*

Münzel, S.C., Langguth, F., Conard, N., & Uerpmann, H. (in press). Höhlenbärenjagd auf der Schwäbischen Alb vor 30.000 Jahren. *Archaeologischen Korrespondenzblatt.*

Münzel, S.C., Morel, Ph. & Hahn, J. 1994. Jungpleistozäne Tierreste aus der Geissenklösterle-Höhle bei Blaubeuren. *Fundberichte aus Baden-Württemberg,* 19/1: 63-93.

Riek, G., 1973. Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 4/I. Stuttgart: Müller & Gräff.

Schmidt, R.R. 1912. *Die diluviale Vorzeit Deutschlands*. Stuttgart: Schweizerbart.

Wagner, E. 1983. Das Mittelpaläolithikum der Großen Grotte bei Blaubeuren (Alb-Donau-Kreis). Forschungen und Berichte Vor- und *Frühgeschichte in Baden-Württemberg* 16. Stuttgat: Theiss.

Walter, H. & Breckle, S. 1983. *Ökologie der Erde (3 vols.): Vol. 1: Ökologische Grundlagen in globaler Sicht.* Stuttgart: Fischer

Weinstock, J. 1999. The Upper Pleistocene mammalian fauna from the Große Grotte near Blaubeuren (southwestern Germany). *Stuttgarter Beiträge zur Naturkunde*, Serie B, 277: 1-49.

The role of mammoths in Upper Palaeolithic economies of southern Germany

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SUMMARY: New analysis of the *Mammuthus primigenius* remains from the Aurignacian deposit at Vogelherd, Germany offers information on age class distribution and skeletal element representation. A minimum of 28 (MNI) mammoths distinguishes Vogelherd as one of the key mammoth sites in central Europe. Evaluation of mammoth data from Vogelherd and other contemporaneous sites in southern Germany provides insight into the role of mammoths in Upper Palaeolithic economies in the context of changing environmental conditions throughout the late Pleistocene.

1. INTRODUCTION

The Swabian Alb region of southern Germany contains a concentration of prehistoric cave sites in the extensive karst systems of the Ach and Lone Valleys that were occupied throughout the Middle and Upper Palaeolithic. The woolly mammoth (*Mammuthus primigenius*) played an important role in Upper Palaeolithic economies as a source of raw material for bone and ivory tools, ivory artworks, building materials, fuel, and probably food.

Indisputable evidence of mammoth hunting has not yet been documented in southern Germany, although mammoth remains are found in 90% of cave localities in this region during the Upper Palaeolithic (Gamble 1986:313, Table 7.4). Most sites contain just sparse bone, tooth, and ivory fragments that only hint at the presence of mammoth, but exceptions to this include the Aurignacian deposits at Vogelherd (31900-27600 bp, ^{14}C, Hahn 1993:219, Tab. 1) and Geissenklösterle (40200 +/- 1500 bp, mean TL and 38400 +/- 850 bp, mean ^{14}C-AMS, Richter *et al.* 2000). Vogelherd contained the remains of at least 28 mammoths, distinguishing it not only in the region but as one of the key mammoth sites in central Europe. At Geissenklösterle, mammoth is represented by partial skeletal remains of two infantile individuals as well as numerous rib and ivory pieces (Münzel 1999).

2. THE VOGELHERD MAMMOTHS

2.1 Dentitions

Based on maxillary molars, 28 mammoths (MNI) were recovered in the Aurignacian deposit. The MNI from this recent analysis of the Vogelherd mammoths differs from an earlier published estimate of 24 individuals (Lehmann 1954). A total of 86 molars, six deciduous tusks, and 55 miscellaneous tooth fragments make up the Aurignacian mammoth dentition assemblage at Vogelherd.

The presence of six deciduous tusks is remarkable, as they are rarely if ever recovered from archaeological or paleontological contexts due to their small size and fragile structure. Based on overall morphology and stage of development, it was determined that these tusks represent six infantile mammoths and ages ranging from two- to 12 months were estimated by comparison with specimens from Russia (Kuzmina & Maschenko 1999).

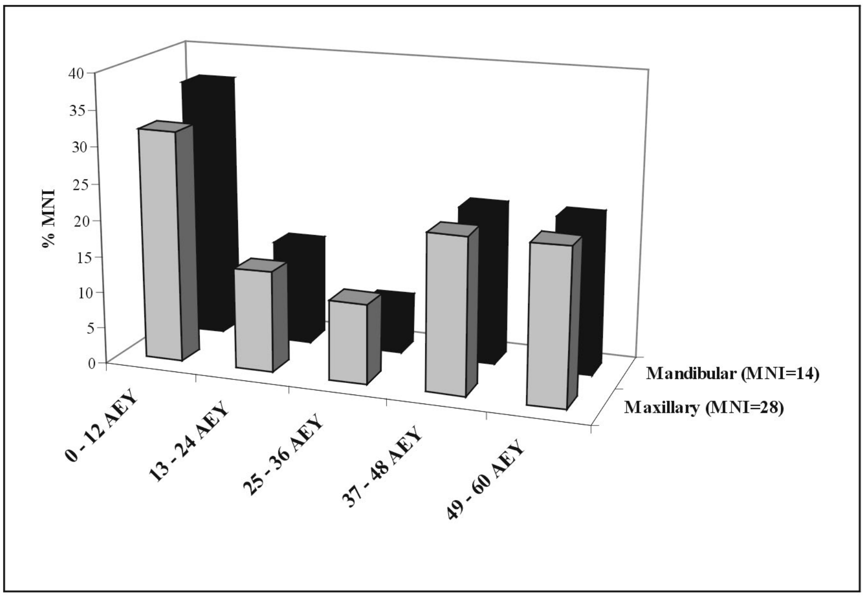

Fig.1 - Age profile for *Mammuthus primigenius* from the Vogelherd Aurignacian deposit

Whether these mammoths perished together, in smaller numbers, or in single mortality events cannot be determined, nor is the cause of death known.

All but two molars were isolated; therefore upper and lower molar sets were analyzed separately and respective MNIs were tabulated. Sixty-seven molars were aged using the system for African elephants in Laws (1966), Jachmann (1985), and Craig (in Haynes 1991) and are listed in equivalent African Elephant Years (AEY).

The age profile reflects selective deaths of individuals from all age groups, most likely the result of time-averaged, cumulative single mortalities as opposed to a one-time catastrophic kill event (Fig. 1). A high proportion of subadults is common in nearly all types of proboscidean death assemblages, as these age classes are more vulnerable to death by predation or natural causes (Haynes 1987). Presence but not predominance of the young adult and adult age classes is also seen at Vogelherd and characteristic of selective or non-selective proboscidean death assemblages. Vogelherd differs from many proboscidean sites in its proportions of the adult and old adult classes. Like juveniles, old animals are more susceptible to death by predation, disease, and nutritional stress and thus an age profile showing similar numbers of these age classes might reflect repeated, single mortalities by these causes. The Vogelherd age profile might also reflect opportunistic predation by humans of single animals or small groups from all age classes at sources of water, vegetation, or minerals. Periods of drought or extreme cold would have forced mammoths to concentrate near water and patches of vegetation (Conybeare & Haynes 1984; Haynes 1991) and proboscideans' dietary dependence on sodium and calcium is known to drive them to isolated sources (i.e. Redmond 1982). Hunting of proboscideans or scavenging of carcasses from natural deaths at such locations have been proposed at several prehistoric sites in both Eurasia and North America (Abracskinskas 1994; Derevianko *et al.* 2000; Haynes 1999), and such scenarios may be reflected in the Vogelherd age profile. The site is approximately 200 m from a river and is located in a limestone outcrop, a probable source of both sodium and calcium.

2.2 Skeletal Element Representation

A total of 729 specimens were identified to element (Tab. 1) and 41 long bone fragments and approximately 2500 ivory fragments were documented. The number of petrous and occipital portions suggest that some complete or nearly complete crania were transported into the cave, while the presence of carpals and tarsals attests to transport of articulated limb portions. As a consequence of 70 years in storage and numerous moves, nearly all the bone is broken, with the exception of one complete femur. Differential weathering stages on some of the elements suggests collecting of already weathered bone on the landscape, a scenario proposed at many of the mammoth bone "dwellings" and bone pile sites in central Europe and Russia (Soffer 1993; Wojtal 1997). Similar skeletal element representation between these sites and Vogelherd supports the hypothesis that mammoth bone could have been used as building material at Vogelherd.

3. THE USE OF MAMMOTH RESOURCES

Mammoth bone and ivory were used extensively by Upper Palaeolithic groups in southern Germany (Hahn 1977; Münzel this volume). The most elegant examples are the small ivory figurines depicting animals (mammoth, horse, lion, bovid, bear) and anthropomorphs from Vogelherd, Geissenklösterle, and Hohlenstein-Stadel. Ivory was also used to fashion tools, jewelry, and other objects, while bone spear-points and other tools were produced from mammoth ribs and long bone shaft fragments.

Utilitarian use of mammoth bone at Vogelherd is suggested by a bone pile containing several tusks, molars, scapulae, one mandible, a "smashed" cranium, and other unidentified bone documented in the southern entrance of the cave (Riek 1934:53-54). Taphonomic studies have shown that bone piles can be formed by various natural agents (Frison & Todd 1986; Voorhies 1969) and should therefore not always be interpreted as the result of

Tab.1 - Skeletal element representation listed in number of individual specimens (NISP), minimum number of elements (MNE), and minimum number of individuals (MNI) for *Mammuthus primigenius* from the Vogelherd Aurignacian deposit.

Skeletal Element	NISP	MNE	MNI
Cranium			
- Petrous Portion	16	17	8
- Occipital Condyle	15	9	7
- Other	358	-	-
Mandible	13	4	3
Molars/Tooth Frag.	147	86	28
Scapula	54	8	8
Humerus	11	6	3
Radius	2	1	1
Ulna	10	2	2
Carpals	3	4	2
Innominate	20	2	1
Femur	13	6	4
Patella	1	1	1
Tibia	4	2	2
Tarsals	1	1	1
Phalanges	5	4	2
Vertebrae	11	8	1
Ribs	45	8	1

cultural processes, but considering that Vogelherd has three entrances, Aurignacian people might have used bulky elements such as the cranium, mandible, innominate, and scapula to construct some sort of barricade or closure against weather, carnivores, or both. The bone pile might also have been a fuel supply, as wood would have been scarce in the glacial steppe.

The abundance of crania might indicate that this element was used as a source of food in addition to building materials and/or fuel. The cranium would have provided a rich source of fats and nutrition in addition to the substantial meat resources from limb elements, although there is no evidence of cut marks or impact fractures on the Vogelherd mammoth bone that indicates butchery or processing.

4. CONCLUSIONS

Evaluation of mammoth data from Upper Palaeolithic cave sites in the Swabian Alb region highlights three primary points: 1) although mammoth is nearly always present in archaeofaunas, the amount tends to be small with the exception of Vogelherd and Geissenklösterle, 2) rich bone and ivory tool inventories point to specific use of mammoth resources during the Aurignacian, and 3) significantly larger amounts of mammoth were transported into Vogelherd cave for several possible reasons, including but not limited to use as building materials, fuel, and food.

It would be exaggerating to say that hunter-gatherer groups focused on mammoth at Vogelherd, since horse was present in nearly equal numbers (MNI = 24) in the Aurignacian deposit. However, in comparison to neighbouring sites, the abundance of mammoth at Vogelherd points to a different use of this cave during the Aurignacian and raises questions about its place in the regional settlement system. This observation also suggests that fluctuating environmental conditions could have influenced the location and number of mammoths in the local area, provided natural death sites to collect bone, possibilities for opportunistic hunting, or both. The mammoth data raise many intriguing questions that will be explored in the ongoing research on the entire faunal assemblage from Vogelherd.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Abracsinskas, L.M. 1994. The distribution of Pleistocene proboscidean sites in Michigan: a cooccurence analysis of their relation to surface saline water. *Michigan Academician*, 17: 65-80.

Conybeare, A. & Haynes, G. 1984. Observations on elephant mortality and bones in water holes. *Quaternary Research* 22: 189-200.

Derevianko, A.P., Zenin, V.N., Leshchinskiy, S.V. & Maschenko, E.N. 2000. Peculiarities of mammoth accumulation at Shestakovo site in west Siberia. *Archaeology, Ethnology & Anthropology of Eurasia*, 3 (3): 42-55.

Frison, G.C. & L.C., Todd. 1986. *The Colby mammoth site: taphonomy and archaeology of a Clovis kill in northern Wyoming*. Albuquerque: Univ. New Mexico Press.

Gamble, C. 1986. *The palaeolithic settlement of Europe*. Cambridge: University Press.

Hahn, J. 1977. *Aurignacien. Das ältere Jungpaläolithikum in Mittel- und Osteuropa*. Köln/Wien: Fundamenta A/9.

Hahn, J. 1993. Geschichtliche Forschung der

Ostalb. *Karst und Höhle*: 213-224.

Haynes, G. 1987. Proboscidean die-offs and die-outs: age profiles of fossil collections. *J. Archaeological Science,* 14(6): 659-668.

Haynes, G. 1991. *Mammoths, mastodonts, and elephants: biology, behavior, and the fossil record*. Cambridge: University Press.

Haynes, G. 1999. The role of mammoths in rapid Clovis dispersal. In G. Haynes, J. Klimowicz, & J.W.F. Reumer (eds.), *Mammoths and the mammoth fauna: studies of an extinct ecosystem*: 9-38. Deinsea 6.

Jachmann, H. 1985. Estimating age in African elephants. *African J. Ecology,* 23(3): 199-202.

Kuzmina, I.E. & Maschenko, E.N. 1999. Age morphological changes in the skull and skeleton of mammoth calves of the Russian plain. In I.E. Kuzmina (ed.), *Mammoth calves Mammuthus primigenius,* 51-120. Proc. Zool. Inst. Russian Acad. Sci Vol. 275, St. Petersburg.

Laws, R.M. 1966. Age criteria for the African elephant *Loxodonta a. africana. East Afr. Wildlife* J., 4: 1-37.

Lehmann, U. 1954. Die fauna des „Vogelherds“ bei Stetten ob Lontal (Württemberg). *N. Jahrbuch f. Geologie u. Paläontologie,* 99(1): 33-146.

Münzel, S. 1999. *DFG-Abschlussbericht zur Großsäugerfauna aus dem Geissenklösterle.* Manuscript on file, Institut für Urgeschichte, Universität Tübingen.

Redmond, I. 1982. Salt mining elephants of Mount Elgon. *Swara,* 5: 28-31.

Richter, D., Waiblinger, J., Rink, W.J. & Wagner, G.A. 2000. Thermoluminescence, electron spin resonance and ^{14}C-dating of the late middle and early upper palaeolithic site of Geissenklösterle Cave in southern Germany. *J. Archaeological Science* 27: 71-89.

Riek, G. 1934. *Die Eiszeitjaegerstation am Vogelherd im Lonetal*. Tübingen: Akademische Verlagsbuchhandlung.

Soffer, O. 1993. Upper paleolithic adaptations in central and eastern Europe and man-mammoth interactions. In O. Soffer & N. Praslov (eds.), *From Kostenki to Clovis: Upper Paleolithic-Paleo-indian adaptations*: 31-49.

Voorhies, M.R. 1969. *Taphonomy and population dynamics of an Early Pliocene vertebrate fauna, Knox County, Nebraska*. Contr. Geology No. 1. Laramie: University of Wyoming.

Wojtal, P. 1997. The number of mammoths (*Mammuthus primigenius*/Blumenbach) at the site Cracow Spadzista Street B. *Anthropozoologica,* 25-26: 803-805.

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Mammoths from Upper Palaeolithic sites in the Ardèche (France)

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SUMMARY: The province of Vivarais, which coincides with what is now the department of the Ardèche, lies between the Massif Centrale and the Rhône valley. Human occupation of the area during the Upper Palaeolithic has left traces along what were the two main routes of communication, the Rhône river basin to the East and that of the Ardeche to the South. A first phase of research, added to by more recent work, has enriched our knowledge of the inhabitants of the area during the Upper Palaeolithic. Analysis has confirmed the presence of various open sites, Valence and Pont Saint Esprit in particular, along the loess at the edge of the Rhône valley; numerous remains of *Mammuthus primigenius* have come to light in these deposits.

1. HUNTER SITES IN THE CHARMES AND SOYONS LOESS

“La Vallée morte de Toulaud” lies on the right bank of the river Rhône at the limit of the granite massif of the Vivarais. During the pre-Pliocene and the early quaternary this would have been the bed of the river Rhône. The river shifted to the East during the Mindel to the course it follows to this day.

Numerous sediments were deposited in the area in question during this phase, including an important sequence of Wurmian loess. A variety of Palaeolithic sites have been identified within the sequence, Charmes and Soyons amongst them. These eolic deposits are scattered the length of the Rhône valley (from Crussol). These are made up of very fine yellowish carbonate deposits, though there is no stratification that brings to mind the loess of the Lyons region.

A typical fauna of small gastropods – *Helix arbustorum* L., *Clausilia laminata* M., *Pupilla muscorum* L. and *Succinea oblonga* M. - is present in the deposits between Saint Peray to the North and Baix to the South. In the southern areas such as Saint Martin and Saint Marcel the number of malacofauna diminishes; in fact only three species have been distinguished - *Pupilla muscorum*, *Fructicicola hispida* and *Limnea* sp.. On other sites there are no organic remains at all. This was pointed out by Roman (1950) and Mazenot (1956) in Bourg-Saint-Andiol.

1.1 Charmes: the Tayac site

In 1938 various bone fragments came to light during agricultural work in a field on the right bank of the Rhône. In September of the same year P. Paya began an archaeological excavation of the loess deposits sealing the bone scatter. A few mammoth remains and stone artefacts were recovered. The bone fragments were originally identified as *elephas intermedius*, given the analogy of the finds with others discovered at Bel on the other side of the river (between Saint-Vallier and Beaussemblant). Baudouin identified the stone artefacts as an Aurignacian industrial assemblage for hunting and subsequent butchery. Further excavations brought to light a skull with its two tusks, the jaw bone and other bone fragments (including a tibia) in the same context as a large quartzite aménagé cobble tool. J. Laurent identified the bone remains as *Elephas trogontheri*, and this, as well as the presence of the cobble tool has led to a very early date being given to the site.

In 1950 J. Combier re-examined the P. Paya collection and identified the jawbone of a reindeer and the metapodium of one of the family of bovidae. Further analysis by R. Vaufrey confirmed these results and led to the original identification of the "*elephas*" to be altered to "*Elephas primigenius*".

Thus, only after the sedimentological study carried out by F. Bourdiere in 1962 and documentation during the excavation followed by more recent analysis by J. Combier and subsequently P. Ayroles in 1973 has it been possible to date this butchery site to the Upper Palaeolithic.

In particular the industrial assemblage and the characteristics of the flakes appear to fit in with the overall picture of gravettian sites in "la Vallée morte de Toulaud".

1.2 Soyons:the Jaulan and Lèches sites

Various archaeological finds came to light during urban construction work to the west of the village of Soyons in 1982. These included four molars from a mammoth, a few bone fragments and a blunt-backed knife. All were entirely embedded within the loess deposit. Finds analysis dated the site to the Upper Palaeolithic.

The site lies on the Southern slopes of the Serre de Saint-Christol between two minor watercourses. In 1986 a rescue dig uncovered the fragmentary remains of an *Elephas primigenius*. The excavation concentrated on Layer 3. Part of the skull with two molars was recovered, as were the tusks (in a very bad condition), the jaw (this too with two molars), the atlas, various vertebrae in their anatomical position, the ribs and two heel bones. The limbs and pelvis were missing. The reason for their absence could lie at the hands of the prehistoric hunter group but it is more likely the result of the intensive modern urbanisation in the area. There is evidence, however, of deep incisions on some of the bone fragments. The industrial assemblage, though fairly limited, could be taken to identify this as a butchery site for large animals (G. Onoratini *et al.*1995).

The industrial assemblage includes a flat faced point, a fragment of a backed knife, fragments of retouched knife blades and denticulates, a calcareous-siliceous flake with visible use-wear traces, and a broad truncated knife. All these finds fit happily within a Gravettian context. They can be associated with open settlements further to the North, such as Méret.

2. The settlement sites on the loess of Saint Martin d'Ardèche

The eolic sedimentary deposits on the right bank of the Rhone run as far south as Pont Saint Esprit. These deposits tend to be found in the side valleys such as the Escoutay (the Bouzil gravettian site) and the Ardèche further to the south.

The open settlement site of Blanchisserie was found in 1978 on the right hand slopes of the latter gorge. It has now all but disappeared. The site was interpreted as an encampment for hunters from the Magdaleine. It lay on the pebbly silt deposits that had subsequently been buried beneath silty eolic sediments. The finds record from the site consisted of a homogeneous industrial lithic assemblage and a few bones. There were 223 bone finds in all. 38 were identifiable. 185 bone slivers were too small and too badly preserved to identify. The faunal record included the following: *Rangifer tarandus*, *Equus caballus*, and *Mammuthus primigenius*. The state of preservation of the identified bone finds is mediocre. Manganese residues and resultant alteration to the bone surface has hindered any attempt to identify butchery marks and signs of deboning of the meat. However it has been possible to distinguish fresh fractures on some of the bones, though only rarely has the original point of impact been identified. The faunal association would suggest a cold and dry climate.

The industrial lithic assemblage includes frequent knapping debris. The surface of the lithic finds is well preserved. About a hundred finds can be placed in the Upper Magdalenian (Onoratini & Joris 1995). There is no absolute date for the deposit but given the sedimentological context of loess sands one could assume that the industrial assemblage is associated with a very cold period close to the glacial maximum, possibly the early Dryas I.

The industrial assemblage is relatively interesting from a typological viewpoint as it ties in with typical elements of the local Salpêtrien. These include frequent backed knives, truncations and typically Solutrian elements. The abundance of burins and the presence of "archaic" elements could place the assemblage in the Magdalenian II (Salpêtriere layers 18-15). In the traditional industrial assemblage there are few transversal burins, triangles or other Aurignacian elements.

3. CONCLUSIONS

In summing up it is interesting to note that while our attention is focused on a fairly rare species as far as the Mediterranean zone is concerned, mammoth remains appear to be relatively frequent in the Gard and Ardèche regions. It is also clear from various site evidence that these remains are to be found in natural "traps" such as dolinas or swamps.

Analysis underway at the moment, which involves a revision of previous site records and their integration with more recent documentation, suggests that these beasts were not only hunted and killed in some of these spots but also butchered.

The sites where mammoth remains have come to light that have so far been analysed appear to date to between 25,000 and 15,000 BP. This would tie them nicely to the Gravettian, Solutrian and Upper Magdalenian butchery sites.

4. BIBLIOGRAPHY

Ayroles, P. 1973. L'industrie et la faune du loess récent de Taillac à Saint-Georges-les-Bains (Ardèche). *Etudes préhistoriques*, 7: 9-12.

Bourdier, F. 1962. *Le Bassin du Rhône au Quaternaire. Géologie et Préhistoire*. 2vol., pp. 364 et ss., CNRS, Paris.

Combier, J. 1967. *Le Paléolithique de l'Ardèche. Publ. de l'Institut de Préhistoire de l'Université de Bordeaux*, 4: 462pp., 178 fig., 21 tabl.

Dalpra, G. 1986. L'Habitat Paléolithique de plein-air: "les Lèches" à Soyons (Ardèche). *Ardèche Archéologie*, 3: 8. juin 1986.

Mazenot, G. 1956. Recherches sur les faunes malacologiques du loess récent würmien et des divers limons holocènes du Sud-Est de la France. *Bull. Soc. Linn. Lyon*, 25: 9-24, 41-56 et 73-85.

Onoratini, G., Dal-Pra, G., Defleur, A., Cregut-Bonnoure, E. & Magnin, F. 1995. Découverte d'une aire de dépeçage de *Mammuthus primigénius* dans la moyenne vallée du Rhône. Le site des Lèches à Soyons, Ardèche (France). *C.R. Acad. Sc. Paris*, 231, IIa: 441-446.

Onoratini, G., Joris, C. 1995. *Nouvelles données sur le Magdalénien en Ardèche. Colloque International El Mon Mediterrani desprès del pleniglacial (18,000 - 12,000 BP)* 18-20 mai 1995, Banyoles.

Paya, P. 1939. Découverte d'un "*Elephas trogontherii*" ou "*intermedius*" à Taillac, entre Charmes et Saint-Georges-les-Bains (Ardèche): Imp. moderne, Privas 1939, 1 fas. 46p (contenant un extrait du *Bull. Soc. Prèhist. Fr.*, 36, 4: 203-211).

Mammoth and subsistence practices during the Mid Upper Palaeolithic of Central Europe (Moravia, Czech Republic)

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SUMMARY: Accumulations of mammoth remains, associated with a variety of archaeological artefacts (Gravettian complex), are found in Mid Upper Palaeolithic large open air settlements from Moravia (Czech Republic). These settlements belong to the Würmian Pleniglacial (Isotope Stage 2) before the Last Glacial Maximum. The human influence on the origin of these bone heaps remains unclear. Zooarchaeological analyses have shown that the Milovice G big mammal assemblage is dominated by *Mammuthus primigenius*. An interpretation of the mammoth bone heap setting in this Central European area is proposed comparing it to other sites.

1. INTRODUCTION

Large Upper Palaeolithic open air sites have yielded huge accumulations of mammoth bones in Central Europe, in the Moravian area of the Czech Republic, and in southern Poland. These famous settlements belong to the archaeological Gravettian complex (Otte 1981, Kozłowski 1986), formed during the first part of the last Würmian Pleniglacial (beginning of Isotope Stage 2, about 29,000-21,000 BP), before the Last Glacial Maximum. The Czech Republic settlements include Předmostí in Central Moravia, and Dolní Věstonice, Pavlov, and Milovice in South Moravia. Large human settlements were discovered, with rich and varied archaeological assemblages of stone and bone artefacts. Furthermore, collective as well as single burials, and ceramic figurines (mammals and Venuses) were found. These are the oldest figurines known at date.

The way the Palaeolithic people procured mammoth remains is still unclear. The mere association of mammal fossils and archaeological implements does not necessarily mean that these mammals were hunted. The occurrence of Proboscidean bones in an archaeological context can be explained by three hypotheses: hunting, scavenging or bone collecting. In both latter cases, the mammoth death is due to another predator than humans, or to a non-biological factor. Our attempt is to methodologically gather valid zooarchaeological criteria to test these hypotheses (Péan & Patou-Mathis in press), and to apply this analytic reasoning to some Gravettian mammoth sites from Moravia (Péan 2001).

We carried on zooarchaeological studies on the Milovice G big mammal assemblage. The site of Milovice lies on a slope, in a small dry blind valley, in loessic sediments (Oliva 1988). The open and arid palaeoenvironment belongs to the mammoth steppe type (Péan 2001), with local coniferous wooded areas.

A thick Gravettian layer was found in this site (Oliva 1988). The archaeological finds mainly come from sector G: lithic tools, one hearth, one circular structure made of mammoth bones, described as a hut. The lithic implements are mostly small debitage, among which retouched tools are dominated by projectile-shaped elements (gravettes, microgravettes, *fléchettes* and shouldered points). Almost no core was found. The site was interpreted as a place where lithic tools were produced and resharpened. As for worked faunal hard material, only a few hollowed reindeer antlers, sometimes incised, and perforated fossil molluscs were found. There is no worked ivory or bone.

2. MATERIALS AND METHODS

The Milovice G big mammal assemblage is curated in the Moravské Muzeum of Brno (Czech Republic). Zooarchaeological studies were carried on through palaeontological, palaeoecological and taphonomical analyses. The palethnographic interpretations take into account the other palaeoecological studies, and the archaeological context. Mammoth dental development classes are gathered into 5 groups (according to G. Haynes 1991). Skeletal preservation is described through Percentage of Survival (Ps = elementMAU / maximum cMNI). Data from Milovice G is confronted to available quantitative data concerning mammoth bone heaps from other Gravettian settlements of Moravia.

Complementary palaeoecological data from Milovice G is given by stable isotope analyses (^{13}C, ^{15}N) of bone collagen from mammoth and other mammals (carried in collaboration with H. Bocherens, Université Paris 6).

3. RESULTS AND DISCUSSION

In Milovice G, among a total fauna of 40 big mammal individuals, 21 mammoth individuals (cMNI) were identified, including the "hut" bones (Péan 2001, Péan & Oliva, in press). Beside the predominating *Mammuthus primigenius* bones, remains of reindeer, horse, wolf, cave lion, wolverine, fox and hare were also found (Fig. 1).

From the age profile, based on dental criteria, the mammoth population is dominated by young individuals, mainly juveniles and subadults (Fig. 2). Mature adults and old individuals are completely missing.

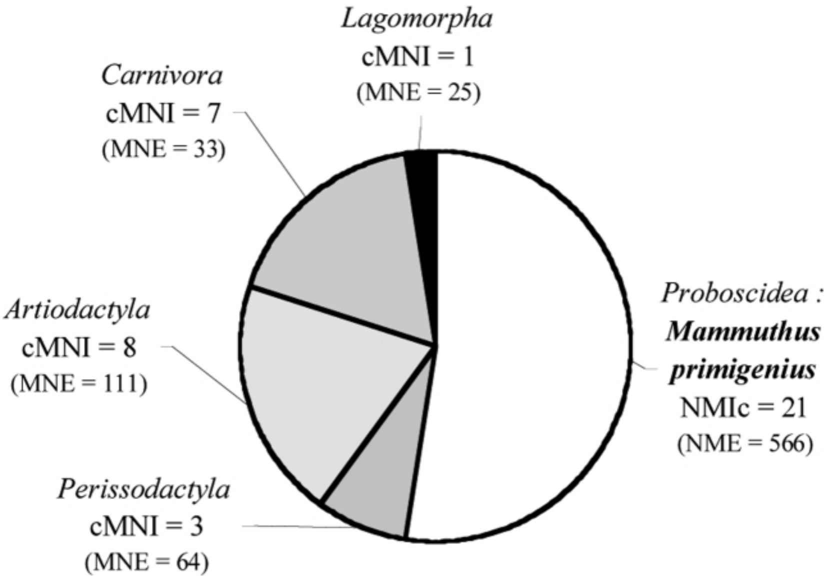


Fig.1 - Large mammals from Milovice G (NME = Minimum Number of anatomical Elements; CMNI = combined Minimum Number of Individuals).

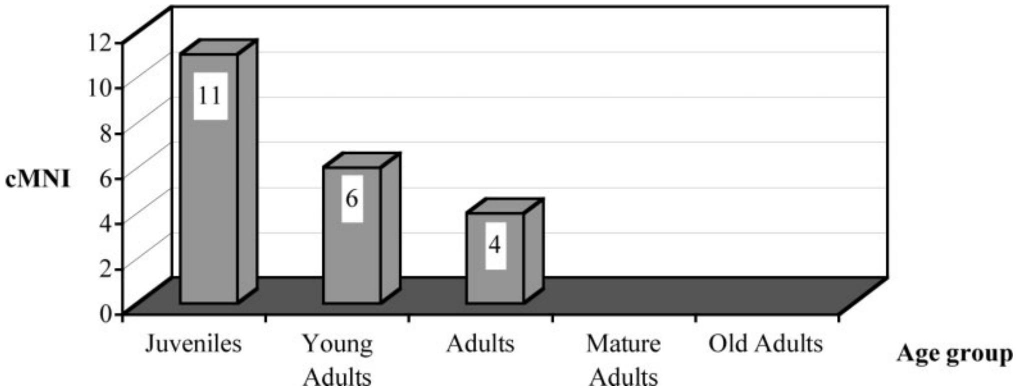


Fig.2 - Milovice G mammoth age profile (from lower molar development stages).

The mammoth bones do not show any anatomical connection. Almost every type of anatomical element was identified among them (except caudal vertebras). There is a low proportion of distal limb bones (especially hand and foot bones), vertebras, and tusks (Fig. 3). Differential preservation may not only explain the reduced proportion of these elements.

Almost all the mammoth remains show a high stage of weathering. Many plant root marks have modified the bone surfaces. Big carnivores activities are limited to gnawing on eight mammoth humerus distal parts. Trampling breakage patterns were noticed.

We interpret the skeletal mammoth preservation as *in situ* deaths of the animals. It is difficult to make a difference between a hunting strategy or a fast access scavenging one. In both cases, it seems that natural traps must have been used in peculiar palaeoenvironmental conditions. Reindeer antler remains and teeth, and a milk tooth of horse refer to a corroborating late spring/early summer season of settlement. At that season, in a Pleniglacial context, yearly mollisol thawing may have created potholes in the clay-loessic sediments of the valley slope where Milovice lies. These indirect observations about seasonality and geomorphological background support the possible role of natural traps in mammoth death.

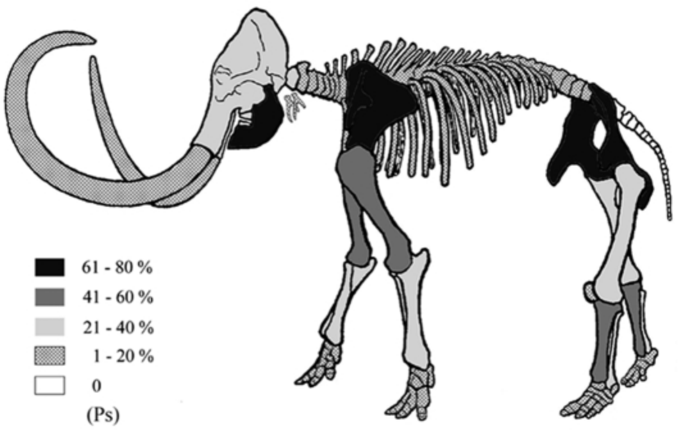


Fig.3 - Milovice G mammoth skeletal preservation (PS=Percentage of Preservation).

The bone accumulating process of the 21 individuals may have occurred during repeated events, as pointed out by the differential collagen preservation, probably in a seasonnal way (Péan, 2001). The catastrophic age profile, without old adults, seems to refer to rather a predator agent than a natural environmental factor.

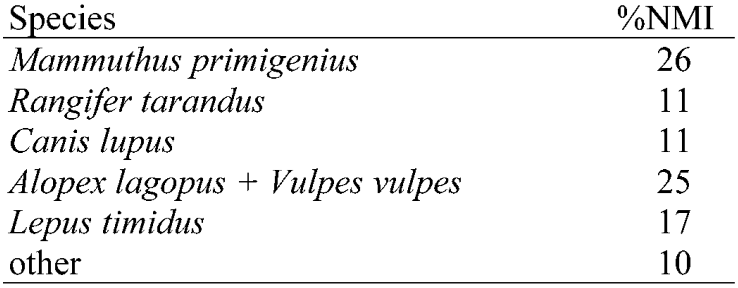
Butchering activities were done in this site. As shown by comparing with modern African elephant butchery sites (Crader 1983), autopodials and tusks were probably taken away by humans. Tusk ivory was probably worked into tools or art support in other Gravettian sites, such as those located in the vicinity of Milovice (Pavlov and Dolní Věstonice). Observed scratches on cranial, axial and limb bones, are probably due to skinning, dismembering, disarticulation and defleshing activities.

Two other wide complex Gravettian settlements lie in the neighbourhood of Milovice, on the Pavlov hills: Dolní Věstonice (I, II and III) and Pavlov (I, II and III).

The global fauna of Dolní Vûstonice I shows predominant, but not so overwhelming, mammoth remains (Table 1). Inside the upper station of Dolní Věstonice I, which apparently yielded 150 individuals (Musil 1959), the identified specimens of the mammoth bone heap No.III are quite well described (Absolon 1938).

In this Dolní Věstonice I mammoth heap, girdle (scapula, hip bone) and limb elements are predominant, fewer autopodials and axial elements are preserved (Fig. 4). There is no information about rib preservation. We think that this preservation scheme is close to the mammoth skeletal distribution in Milovice G. It can be also interpreted as a butchery site, maybe set on the location where the animals died.

Tab.1 - Predominating big mammals from Dolní Věstonice I (after data from Musil 1994).



Species	%NMI
Mammuthus primigenius	26
Rangifer tarandus	11
Canis lupus	11
Alopex lagopus + Vulpes vulpes	25
Lepus timidus	17
other	10

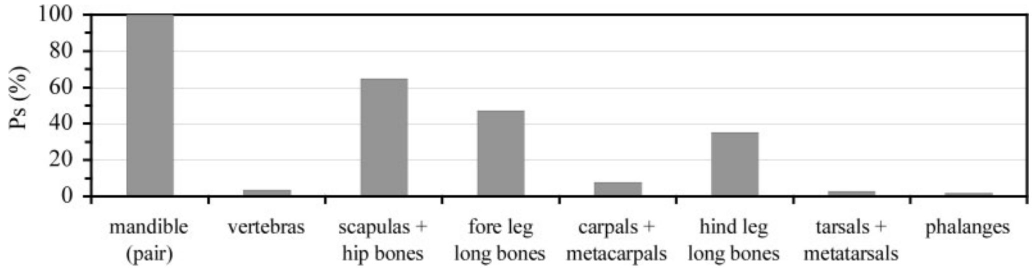


Fig.4 - Mammoth skeletal preservation in the accumulation No.III of Dolní Věstonice I (after counts in Absolon 1938).

In Pavlov I, mammoths are not predominant in every part of the site, and never occur as bone heaps (Musil 1994, 1997). The preservation seems to be linked with the settlement units.

Předmostí is located about 100 km northeastwards, in Central Moravia. The scarce published data about mammoth remains in Předmostí (Kříž 1896) show a better preservation of cranial and limb bones, and also girdle elements. We think that the low proportion of autopodial parts, and an apparent lack of axial parts, would be due to an anthropic activity of butchery.

4. CONCLUSION

Among the whole Gravettian cultural complex in Central Europe, mammoth bone heaps only appear in the Moravian large open air settlements, and one site of southern Poland, Kraków-Spadzista. In other Gravettian sites of Eastern Central Europe, subsistence is mainly based on reindeer, several other ungulates, and hares (Péan 2001). Mammoth is there an exceptional food procurement, mainly brought to the camp as parts of carcasses, possibly scavenged. Conversely, the Moravian mammoth accumulations, except in Pavlov, look like butchery places on the death location, like in Milovice G. We propose that, in these Moravian sites, Gravettian people may have seasonnally gathered, taking advantage of peculiar environmental marshy conditions, to organize collective mammoth trapping. The long termed settlement type of these Moravian sites, as reinforced by exceptional archaeological items, supports this idea. Further zooarchaeological analyses are needed to validate, or not, this attempted interpretation of the huge accumulations of mammoth remains in the Moravian Gravettian sites.

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6. REFERENCES

Absolon, K. 1938. *Die Erforschung der diluvialen Mammutjäger-Station von Unter-Wisternitz in Mähren. Arbeitsbericht über das zweite Jahr 1925*: 101 p. Brünn: Polygrafia.

Crader, D. C. 1983. Recent single-carcass bone scatters and the problem of "butchery" sites in the archaeological record. In J. Clutton-Brock & C. Grigson (eds.), *Animals and Archaeology: 1. Hunters and their prey, BAR International Series* 163: 107-141.

Haynes, G. 1991. *Mammoths, Mastodonts, and Elephants: biology, behaviour, and the fossil record*: 413 p. Cambridge: Cambridge University Press.

Kozlowski, J.K. 1986. The Gravettian in Central and Eastern Europe. In F. Wendorf & A. E. Close (eds.), *Advances in world archaeology* 5: pp. 131-200. New York: Academic Press.

Kříž, M. 1896. Mé výzkumné práce u Předmostí a jich hlavní výsledky. *Časopis Vlast. mus. sploku Olomouc* 13: 1-9/51-61/87-102.

Musil, R. 1959. Poznámky k paleontologickému materiálu z Dolních Věstonic. *Anthropozoikum*, 8/1958: 73-82.

Musil, R. 1994. Hunting game from the culture layer at Pavlov. In J. Svoboda (ed.), *Pavlov I: excavations 1952-1953 The Dolní Věstonice Studies, Volume 2, ERAUL* 66: 170-196.

Musil, R. 1997. Hunting game analysis. In J. Svoboda (ed.), *Pavlov I – Northwest : The Upper Palaeolithic burial and its settlement context*: 403-424. Brno: Academy of Sciences of the Czech Republic, Institute of Archaeology.

Oliva, M. 1988. Discovery of a Gravettian mammoth bone hut at Milovice (Moravia, Czechoslovakia). *Journal of Human Evolution*, 17: 787-790.

Otte, M. 1981. *Le Gravettien en Europe centrale.* Dissertationes Archaeologicae Gandenses XX, Brugge: De Tempel, 2 vol.: 504 p.

Péan, S. 2001. *Comportements de subsistance* *au Gravettien en Europe centrale (Autriche, République tchèque, Pologne, Hongrie)*. Thèse de doctorat du Muséum National d'Histoire Naturelle, Paris: 413 p. *Unpublished*.

Péan, S. & Oliva, M. in press. Mammoth and man, 25000 years ago, at Milovice (South Moravia, Czech Republic): first results of a zooarchaeological study in sector G. In *Proceedings of the International Conference on Mammoth Site Studies, March 11-13 1998*. Lawrence: University of Kansas.

Péan, S. & Patou-Mathis, M. in press. Taphonomy of mammoth sites. In W.F. Reumer, F. Braber, D. Mol & J. de Vos (eds.), *Advances in Mammoth Research*. Rotterdam: Deinsea.

The Pleistocene Gomphotheres (Proboscidea) from South America: diversity, habitats and feeding ecology

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SUMMARY: Gomphotheres were recorded in South America from the early-middle Pleistocene (Ensenadan Land-mammal Age) to the late Pleistocene (Lujanian Land-mammal Age). They arrived in South America during the “Great American Biotic Interchange”. Only two genera are recognised: *Cuvieronius*, which has only one species, *Cuvieronius hyodon*; and *Stegomastodon*, which has two species, *Stegomastodon waringi* and *Stegomastodon platensis*. The small *Cuvieronius* utilised the Andean corridor and it was almost exclusively mixed-feeder. The large *Stegomastodon* dispersed through the east route and the coastal area, where *Stegomastodon waringi* shows an adaptive trend from mixed-feeder to grazer, and *Stegomastodon platensis* shows a trend from mixed to browser feeding. *Cuvieronius* seems to have been adapted to a temperate-cold climate conditions, while *Stegomastodon* seems to have predominated in lower latitudes, and was better adapted to warm or temperate climatic conditions.

1. INTRODUCTION

The proboscidea gomphotheres (family Gomphotheriidae) are known in South America from the early Pleistocene (Ensenadan Land-mammal Age) to the late Pleistocene (Lujanian Land-mammal Age). They were descendants of the gomphothere stock that originated in North America and arrived in South America during the “Great American Biotic Interchange” (Webb 1991). Only two genera are recognized: *Cuvieronius*, which has only one species, *Cuvieronius hyodon*; and *Stegomastodon*, which has two species, *Stegomastodon waringi* and *Stegomastodon platensis* (Alberdi & Prado 1995; Alberdi *et al.* in press). Recently, Casamiquela *et al.* (1996) presented a simplified classification modified after Simpson & Paula Couto (1957), and Shoshani (1996) suggested including all South American gomphotheres into the subfamily Cuvieroniinae. In any case, the problem of nomenclature is a complex one. *Cuvieronius hyodon* is geographically restricted to the Andine Region of Ecuador, Peru, Bolivia, Chile and Northwest Argentina. *Stegomastodon waringi* has been recorded in Brazil and Ecuador (on the Santa Elena peninsula and in the Quebrada Pistud locality, near Bolivar province of Carchi). *Stegomastodon platensis* has been recorded in Argentina from the middle to the latest Pleistocene, principally in the Pampean Region, and also in Uruguay and Paraguay during the late Pleistocene.

During the Pleistocene, two corridors developed in South America. These two corridors shaped the paleobiogeographic history of most North American mammals in South America. The most viable model postulated for the gomphothere dispersal process seems to indicate that the small *Cuvieronius* utilised the Andes corridor, whereas the large Stegomastodon dispersed through the East route and some coastal areas.

2. FEEDING AND HABITAT

Generally, it is considered that the habitat of *Cuvieronius* would have been high grassland with cold to temperate climatic conditions, while *Stegomastodon* would have been adapted to more open grassland with warm to temperate climatic conditions. By means of isotopic analyses, Sánchez *et al.* (in press) have analysed the diet of different gomphothere species from Pleistocene deposits of South America, and have reconstructed the diet of *Cuvieronius hyodon, Stegomastodon waringi* and *Stegomastodon platensis.*

The carbon isotopic results for *Cuvieronius* and *Stegomastodon* from the middle Pleistocene indicate different feeding ecologies for these two genera. *Cuvieronius* from Tarija has isotopic values that are more homogeneous. These values agree with those previously described by MacFadden & Sockey (1997), and indicate that this genus was predominantly a mixed-feeder. On the other hand, *Stegomastodon platensis* from middle and late Pleistocene of Argentina exhibits more negative isotopic values, suggesting an adaptive trend from mixed-feeding to browser-feeding (Sánchez *et al.*, in press). In addition, isotopic composition in *S. waringi* from the late Pleistocene of Santa Elena Peninsula, Ecuador, suggests that this species was a mixed-feeder with grazer tendencies. This may be related to the altitudinal and latitudinal distribution of this species.

There appears to be no biological explanation why *Mammuthus* (Elephantidae) and *Mammut* (Mammutidae), recorded in Florida and Honduras during the Pleistocene, and which might have been expected to cross the Panamanian land bridge, did not reach South America (Koch *et al.* 1998). The reasons may be found in the diet and habitat preferences of these genera. Mastodons (*Mammut*) have relatively low-crowned molars with cusps arrayed in widely spaced lophs. This dental morphology led to the recognition of mastodons as browsers (Webb *et al.* 1992). Mammoths (*Mammuthus*) have high-crowned molars with closely spaced enamel lophs coated with cement, which identifies them as grazers (Davis *et al.* 1985). Isotopic analyses confirm this hypothesis (MacFadden & Cerling 1996). By contrast, the gomphotheres from West Palm Beach, Florida, USA, and from South America have a $\delta^{13}C$ values which are intermediate between browsers and grazers (Koch *et al.* 1998; Sánchez et al. in press). Both *Mammut* and *Mammuthus* were more specialised feeders than *Cuvieronius*, which was a mixed-feeder, and *Stegomastodon* which was a mixed-feeder with tendencies toward browser-feeding or grazer-feeding (see above). These observations do not match the predictions of Vrba's (1992) model, who indicated that forms that would have tended to disperse from north to south would have been more adapted to open environments, and consequently would have been predominantly grazers.

3. GOMPHOTHERE EXTINCTION IN SOUTH AMERICA

There are many causes for Pleistocene mammal extinction, which make it difficult to consider and evaluate all of the complex phenomena that produced the disappearance of an important part of the Pleistocene fauna. Two types of theories have been offered for this extinction: the direct impact of man through hunting activities and climate and ecological changes.

Martin (1984) proposed that the extinction of large mammals from America and Australia are related to various, sudden human impacts. The overkill hypothesis is supported by the synchrony of extinction with the arrival of large numbers of humans in these continents. It seems that human activities, such as hunting pressure or habitat disturbance, affected the Pleistocene population of gomphotheres (Politis *et al.* 1995). The archaeological record from South America shows that gomphotheres were common in Paleo-Indian sites (Montané, 1968; Bryan *et al.* 1978; Correal Urrego 1981;

Dillehay & Collins 1988). Prado *et al.* (2001) show that large mammal extinctions were correlated with climate change, a process that began prior to the arrival of humans in the Pampean Region.

Climatic and ecological changes produced rapid change in plant communities. The nutritional stress induced by these changes is identified as the main cause of extinction by Graham & Lundelius (1984) and King & Saunders (1984). This models implies that gomphotheres died off because they were specialised feeders, adapted to a kind of plant that disappeared during the Holocene times. With this in mind, Guthrie (1984) hypothesised that plant diversity was greater and the growing season was longer in the Pleistocene than in the Holocene.

4. FINAL REMARKS

The South American gomphotheres must be included in only one subfamily. We recognise two genera, *Cuvieronius* and *Stegomastodon*; and three species, C*uvieronius hyodon*, *Stegomastodon waringi*, and *Stegomastodon platensis*.

Cuvieronius genus arrived in South America during the Great American Biotic Interchange, and was recorded from the early Pleistocene to the late Pleistocene utilising the Andes corridor for its dispersal. The genus *Stegomastodon* appeared later, during the middle Pleistocene and dispersed through the East route and some coastal areas.

Cuvieronius was a mixed feeder, and *Stegomastodon* was a mixed-feeder with tendencies toward browser-feeding or grazer-feeding. These differences in diet preferences could explain why only the bunodont forms reached South America when both types, lophodont and bunodont, lived together in North America prior to the emergence of the Isthmus of Panama.

Cuvieronius hyodon would have inhabited high grasslands with cold to temperate climatic conditions, and *Stegomastodon* would have been adapted to more open grasslands with warm to temperate conditions.

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6. REFERENCES

Alberdi, M.T., Cartelle, C. & Prado, J.L. (in press). *El registro de Stegomastodon (Mammalia, Gomphotheriidae) en el Pleistoceno superior de Brasil.* Ameghiniana.

Alberdi, M.T. & Prado, J.L. 1995. Los mastodontes de América del Sur. In M. T. Alberdi, G. Leone & E. P. Tonni (eds.), Evolución biológica y climática de la Región Pampeana durante los últimos 5 millones de años. Un ensayo de correlación con el Mediterráneo occidental. *Monografías, MNCN, CSIC*, 12: 277-292. Madrid.

Bryan, A., Casamiquela, J., Cruxent, J., Gruhn, R. & Ochsenius, C. 1978. An El Jobo Mastodon Kill at Taima-Taima, Venezuela. *Science*, 200: 1275-1277.

Correal Urrego, G. 1981. *Evidencias culturales y megafauna pleistocénica en Colombia*, 12: 1-148. Bogotá: Fundación de Investigaciones Arqueológicas Nacionales.

Casamiquela, R.M., Shoshani, J. & Dillehay, T.D. 1996. South American proboscidean: general introduction and reflections on Pleistocene extinctions. In J. Shoshani & P. Tassy (eds.), *The Proboscidea. Evolution and Palaeoecology of Elephants and their relatives*: 316-320. Oxford, New York, Tokyo: Oxford University Press.

Davis, O.K., Mead, J.I., Martin, P.S. & Agenbroad, L.D. 1985. Riparian plants were a major component of the diet of mammoths of Southern Utah. *Current Research in the Pleistocene*, 2: 81-82.

Dillehay, T.D. & Collins, M.B. 1988. Early cultural evidence from Monte Verde in Chile. *Nature*, 332: 150-152

Grahan, R.W. & Lundelius, E.L. 1984. Coevolutionary disequilibrium and Pleistocene extinctions. In P. S. Martin & R. G. Klein (eds.), *Quaternary extinction: A Prehistoric Revolution*: 223-249. Tucson: University of Arizona Press.

Guthrie, R.D. 1984. Mosaics, allelochemics and nutrients. An ecological theory of late Pleistocene Megafaunal Extinction. In P.S. Martin & R.G. Klein (eds.), Q*uaternary extinction: A Prehistoric Revolution*: 259-298. Tucson: University of Arizona Press.

King, J.E. & Saunders, J.J. 1984. Environmental Insularity and the Extinction of the American Mastodont. In P.S. Martin & R.G. Klein (eds.), *Quaternary extinction: A Prehistoric Revolution*: 315-339. Tucson: University of Arizona Press.

Koch, P.L., Hoppe, K.A. & Webb, S.D. 1998. The isotopic ecology of late Pleistocene mammals in North America. Part 1. *Florida. Chemical Geology*, 152: 119-138.

MacFadden, B.J. & Cerling, T.E. 199). Mammalian herbivore communities, ancient feeding ecology, and carbon isotopes: a 10 million year sequence from the Neogene of Florida. *Journal of Vertebrate Paleontology*, 16: 103-115.

MacFadden, B.J. & Shockey, B.J. 1997. Ancient feeding ecology and niche differentiation of Pleistocene mammalian herbivores from Tarija, Bolivia: morphological and isotopic evidence. *Paleobiology*, 23: 77-100.

Martin, P.S. 1984. Prehistoric Overkill: The Globel Model. In P.S. Martin & R.G. Klein (eds.), *Quaternary extinction: A Prehistoric Revolution*. 354-403. Tucson: University of Arizona Press.

Montané, J. 1967. Investigaciones interdisciplinarias en la ex laguna Taguatagua. Provincia de O'Higgins. Anales de la Academia Chilena de Cinecias Naturales. *Universidad Católica*, 52(30): 327-331

Politis, G.G., Prado, J.L. & Beukens, R.P. 1995. The Human Impact In Pleistocene-Holocene Extinctions. In E. Johnson (ed.), *South America - The Pampean Case. Ancient Peoples and Landscapes*: 187-205. Lubbock, Texas: Museum of Texas Tech University.

Prado, J.L., Alberdi, M.T., Azanza, B. & Sánchez, B. 2001. Quantitative relationship between climate and changes in Mammal diversity during the late Pleistocene-Holocene in the Pampean Region (Argentina). *Acta Paleontologica Polonica*.

Sánchez Chillón, B., Prado, J.L. & Alberdi, M. T. (in press). Isotopic Evidences On the paleodiet of Pleistocene South American Gomphotheres (Gomphotheriidae, Proboscidea). *Paleobiology*.

Shoshani, J. 1996. Para or monophyly of the gomphotheres and their position within Proboscidea. In J. Shoshani & P. Tassy (eds.), T*he Proboscidea. Evolution and Palaeoecology of Elephants and their relatives*: 149-177. Oxford, New York, Tokyo: Oxford University Press.

Simpson, G.G. & Paula Couto, C. 1957. The Mastodonts of Brazil. *Bulletin of the American Museum of Natural History*, 112: 125-190.

Vrba, E.S. 1992. Mammals as a key to evolutionary theory. *Journal of Mammalogy*, 73: 1-28.

Webb, S.D. 1991. Ecogeography and the Great American Interchange. *Paleobiology*, 17(3): 266-280.

Webb, S.D., Dunbar, J. & Newsom, L. 1992. Mastodon digesta from North Florida. *Florida Geological Survey, Special Publication*, 10: 1-59.

The conditions of existence of *Mammuthus primigenius* Blumenbach in the periglacial zone of Eastern Europe

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SUMMARY: This paper presents some material characterizing the conditions of existence of *Mammuthus primigenius* Blumenbach in the periglacial zone of Eastern Europe in the Late Pleistocene. On the basis of data, mainly about small mammals, it has been shown that there were tundra-steppe ecosystems in which mammoths lived.

1. INTRODUCTION

Three major climatic macrocycles are singled out within the limits of the Pleistocene. The first macrocycle is an early Pleistocene or Eopleistocene one (after 1.8 Ma). It is characterized by a general rise and dismemberment of the relief and precedes the beginning of the period of freezing. The second macrocycle is an early Neopleistocene or a middle Pleistocene one (after 0.8 Ma). It is characterised by the rise of the amplitude of the climatic fluctuations and the appearance of temperature contrasts on the background of tectonic sinkings. The third macrocycle is the Late Pleistocene (from 150 ka onwards) with a maximum of climatic oscillaytions and of low temperatures. It led to the formation of a hyperzone or a periglacial zone in the middle of Eastern Europe (Spasskaya *et al.* 1993).

The deposits of the Upper Pleistocene of Eastern Europe are divided into four levels of which the Mikulin level (Eemian) is the warmest while the Valdai (Würm) upper level with interstadials is rather cold. Opinions differ as to the climatic ranks of this period of freezing, its scales and spreading, chronology and stratigraphy of moraine and inter-moraine deposits, interrelation of data, etc. But the presence of the periglacial zone which has specific tundra - steppe conditions and is populated by a set of species in specific ecosystems, has been proved. Low temperature conditions of the early and late Valdai potentially promoted the development of long-time freezing and the formation of river terraces connected with periodic changes of sea level of the Black and Caspian Seas.

Under these conditions, periglacial vegetation survived into the early Valdai and even in the middle Valdai interstadial, the time of the formation of the Bryansk soil. The late - Valdai epoch (25 - 17 ka), with its most rigorous climate, was accompanied by the development of ice cover and the shift of the hyperzone southwards, approximately to the latitude of Kiev and Kanev on the Dniepr (Velichko, 1973).

2. CHARACTERISTIC OF THE PERIGLACIAL CONDITIONS.

Paleobotanical data show that the quantity of tree pollen decreased and that broad - leaved forests disappeared completely. Dominating were the cenoses of the shrub birch (*Betula nana*), a representative of forest - tundra and northern taiga, partially the pine (*Pinus*), the *Efedra* and sphagna bog - mosses (*Sphagnum*). In the epoch of maximum fall of temperature the vegetation was a birch forest – steppe. Tundra herbaceous flora similar to that of modern

West Taimyr prevailed (Paleogeography of Europe 1982). In some regions (Western Dvina) remains of the Arctic - Alpine species have been found **(***Selaginella selaginoides, Salix* ex gr. *polaris, Poligonum viviparum, Potentilla* cf. *nivea*) (Sanko 1987).

The open spaces were a cold steppe with wormwoods and cereals while small shrubs and herbaceous vegetation rich in biomass remained only in river valleys (Grichuk 1973). They were the main food for *Mammuthus primigenius* and other big hoofed animals. Mammoths fed on meadow cereals (*Poaceae*), sedges (*Carex*) as well as on sprouts of trees (willow - *Salix sp*.), birch (*Betula* sp.), alder (*Alnus* sp.). (Vereshchagin & Baryshnikov 1985).

The predominance of tundra - steppe and tundra landscapes is also confirmed by the fauna that populated these cenoses. A peculiar fauna complex formed on the whole territory of the middle zone of Eurasia - a mixed fauna linked to the periglacial zone of the Valdai glacier (Pidoplichko, 1934; Vangengeim, 1976; Nadachowski, 1982; Rekovets, 1985). The main peculiarity of this fauna is the coexistence of various ecosystems or cenoses in the same landscapes. They were populated by both tundra and steppe species of animals at the same time.

The species that are typical of open spaces (steppes, semi - deserts and tundra) make up about 50% of the mammal fauna of the periglacial zone. The number of species of periwater biotopes are within 10 - 17%. Polyzonal species with broad ecological adaptability, mainly predatory animals (*Carnivora*) make up to 30%. Forest species are practically absent.

Arctic species at times spread far beyond the limits of the periglacial area and reached Moldova (*Dicrostonyx*) and the Crimea (*Rangifer, Alopex, Lagopus*) in the South. At the same time the northern spreading of steppe species was limited by the glacier front at an average of 54^0 North. The species of the interzone are smaller in number. They testify the corresponding development of lowered landscapes and water - meadow cenoses. The chronological peculiarities of the Valdai periglacial faunas were determined by the existence of two falls of temperature and of the mid - Valdai rise in temperature. It is expressed mainly by the changing ratios of the species of various ecological groups over time. Toward the maximum of the fall of temperature, the Arctic character of the fauna increased. That is, there was a constant dynamism in the environments. It determined changes of fauna and, in the first place, of mass species (*Dicrostonyx gulielmi, Microtus (Stenocranius) gregalis, Lagurus lagurus, Mammuthus primigenius, Rangifer tarandus, Alopex lagopus*). The landscapes of the periglacial zones and its inhabitants were not homogeneous in latitude and in a meridional direction. In the middle zone of Eastern Europe the periglacial conditions were less different in the meridional direction than in the latitudinal one. The change of conditions and therefore of ecosystems and their inhabitants from the west to the east was less considerable (Alexeeva 1980; Vereshchagin & Baryshnikov 1985). Eastwardly (as far as Zabaikalie), *Mammuthus* and *Rangifer* become rarer, *Ovibos, Alopex, Dicrostonyx* were absent. Typical of these regions are *Poephagus baikalensis, Spirocerus kiakhtensis, Procapra gutturosa, Microtus brandti, Lepus tolai.*

Westwardly, steppe species become rarer and rarer, especially *Ochotona, Allactaga, Lagurini*, while ecologically more adaptable species such as *Apodemus, Arvicola, Microtus oeconomus, Cervus, Capreolus* became more various.

Latitude ecosystems have their own Nort-South gradations. It is fixed as subzones (Vangengeim 1976) or local versions of the Mammoth fauna complex (Bibikova & Belan, 1979). For example, at latitude of 50 - 55^0 North, tundra - steppe with patches of forest - tundra predominated. It was populated mainly by representatives of the genera *Dicrostonyx, Lemmus, Ovibos, Gulo, Mammuthus, Rangifer, Alopex lagopus, Microtus (Stenocranius).*

The quantitative and qualitative composition of this association changed southward. The species of the open steppes, the genera *Ochotona, Spermophilus, Marmota, Allactaga, Lagurus, Eolagurus*, partially *Bison*, were more and more numerous southward.

Such transformations in the system of relatively mixed biocenoses of the Late Pleistocene were uneven in their nature. At the taxonomical level it became apparent through the comparatively quick formation of new species: for example, *Spermophilus severskensis, S. superciliosus*, *Dicrostonyx gulielmi*, *Lepus tanaiticus*, *Ochotona spelaeus*, *Equus latipes*; or transitional subspecies such as *Microtus gregalis kriogenicus, M. oeconomus major, Eolagurus luteus antecedens*, *Lagurus lagurus major* and others. These mammals (mainly small) were specific elements of the periglacial environment, where the taxonomic composition was much variable. The periodically more stable association is characterised by *Arvicola*, *Lemmus*, *Carnivora*. The tendency towards an increase of species diversity of periglacial cenoses in the course of time is quite clearly traced and agrees with the tendency towards a higher specialisation. This is confirmed by the presence of specific morphological differences in the species of the periglacial faunas (Vereshchagin & Baryshnikov 1985; Rekovets 1983). Some species of mammals were larger (*M. (Stenocranius*) *gregalis, M. oeconomus, Lagurus lagurus*), or had more complicated morphostructures of the occlusal surface of molars than extant mammals (*Arvicolidae, Sciuridae*), or had higher tooth crowns (*Lepus, Equus*), or broadened distal parts of the extremities (*Allactaga, Equus*). The morphofunctional analysis of these adaptations confirms that the species of the mammoth fauna lived under conditions of low temperature in open landscapes with xenophile vegetation.

South of 50^0 (the latitude of Kiev and Kanev), the ecosystems were different from the northern or typically periglacial ones more in the quantitative and less in the qualitative taxonomical composition of each ecological groups. *Dicrostonyx* and *M. gregalis* are reduced to 5 - 7 %, *Lemmus* is absent, the number of species of the polizonal ecosystems increases to 30 %, the species of forest ecosystems are up to 5 %. Such a faunal composition, as well as paleobotanical and paleopedological data (Sirenko & Turlo 1986; Udra 1988), testify the existence of much more phytomass in the landscape, with a predominance of sedge – grass vegetation, shrubbery and forest patches. Probably it suggests an increase of the number of mammoth and bison too. These species prevail in the faunas of Mezhyrich, Dobranichevka, Gontsy and other sites (Rekovets 1985). The mammoth took one of the first places in eating the rich vegetation biomass of the tundra - steppe interzone ecosystem. Such conditions are comparable to those of the northern part of West Siberia. There, highly productive tundra - steppe ecosystems predominated in the final phases of Valdai, especially in the river flood plains (Bolikhovskaya 1995). They provided optimal conditions, with a considerable density of mammoth and other herbivores.

3. REFERENCES

Alekseeva, L.I. 1980. Particular features of the theriocomplex of the late interglacial of the Russian plain.*Trudy ZIN AN USSR* 93: 68-74.

Bibikova, V.I. & Belan, N.G. 1979. The local variations of the late palaeontological theriocomplex of South Eastern Europe. *Doc. MOIP, sap. doc.* 84: 3-14.

Paleogeography of Europe. 1982. *Atlas*. Moscow: Nauka.

Pidoplichko, I.G.1934. Finding of mixed tundra and steppe faunas in the sediments of Novgorod - Siverska. *Priroda* 5: 80-82.

Pidoplichko, I.G.1951. *About the glacial period*. Kyiv: AN USSR.

Rekovets, L.I.1983. Morphological particular features of fossil bones of rodents (Rodentia, Mammalia) from Late Pleistocene locations of the subriver Dnieper of Ukraine. *Morphological particularity of vertebrate mammals of Ukraine*: 53-56. Kyiv: Nauk. dumka.

Sanko, A.F. 1987. *New Pleistocene of North - East Bielorussia and nearest regions of RSFSR*. Minsk: Nauka i technica.

Sirenko, N.A. & Turlo, S.I. 1986. *Development of soils and plants of Ukraine during the Pliocene and Pleistocene*. Kyiv: Nauk. dumka.

Spasskya, I.I., Astahov V.I.,Glushkova U.V., *et* *al*. 1993. *Evolution of landscapes and climate of North Eurasia*. Moscow: Nauka.

Udra, I.F. 1988. *Spreading of plants and questions of palaeobiogeograpy*. Kyiv: Nauk. dumka.

Vangengeim, E.A. 1976. Periglacial zone and formation of mammal faunas of USSR in the Holocene. *The history of biogeocenoses of USSR in the Holocene*: 92-101. Moscow: Nauka.

Velichko, A.A. 1973. *Natural processes in the Pleistocene*. Moscow: Nauka.

Vereshchagin, N.K. & Baryshnikov, G.F. 1985. Extinction of mammals in the Quaternary period of Northern Eurasia. *Trudy ZIN AN USSR* 131: 3-40.

Comparisons of stegodon and elephantid abundances in the Late Pleistocene of southern China

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SUMMARY: In the Pleistocene fauna of southern China, *Elephas* coexists with *Stegodon* whose molar structure is more primitive and which presumably fed on more browses than the former. I surveyed the Chinese literature of ca. 180 localities in southern China where *Stegodon* and *Elephas* occur separately or co-occur, to learn if stegodon outnumber elephants in the late Pleistocene fauna of China. I found that stegodon localities significantly outnumber those with elephants. The above results for south China seem to support the Generalist vs. Specialist hypothesis proposed by Shoshani (1992). However, because of the complexities in feeding mechanisms in *Stegodon* and *Elephas*, the definitions of the terms “grazer” and “browser” do not necessary help to distinguish between generalist and specialist taxa. Detailed reconstruction of feeding habits of stegodons is necessary for the evaluation of the present results.

1. INTRODUCTION

Elephas maximus is the only species of the Proboscidea living in present day East Asia, but *Elephas* coexisted with extinct genus *Stegodon* throughout Pleistocene in southern China (Takahashi & Namatsu 2000). Youngest remains of *Stegodon* were found from a Neolithic site (Xiaohe Cave) in Yunnan Province, which is dated at 4100 bp (Ma & Tang 1992). Thus, extinction of the stegodons is a very recent event which occurred during Holocene.

Sympatry of two proboscidean species has been known also from the late Pleistocene of North America, where primitive taxon American mastodons coexisted with derived taxon mammoths. Shoshani (1989) examined the number of proboscidean fossils found from Michigan and found that American mastodons outnumber mammoths in forested area (diverse habitat), and vice versa in open habitat. He argued that relative abundances of proboscideans observed in the late Pleistocene of North America fits his generalist vs. specialist, hypothesis (Shoshani 1992). According to this hypothesis, primitive, generalist taxon outnumber derived, specialist taxon in diverse habitat, if the animals compared share same body size and close phylogenetic relationship.

Census study of the late Pleistocene proboscideans is worth to be conducted not only in North America but also in other area of the world, for instance East Asia, where stegodons and elephants coexisted during Pleistocene. Specialist vs. generalist hypothesis predicts that stegodons must outnumber elephants during late Pleistocene in China, because stegodons are primitive compared to the elephants in molar structure and they were living in forested, diverse habitat. Thus, prime motivation of this study is to test this prediction. However, as noted later, the results obtained through such census studies must have implication not only on generalist vs. specialist hypothesis but also on the of the late Pleistocene extinction of megafauna in East Asia.

2. LITERATURE SURVEY

2.1 Tong-Liang case

The objective of this study is learn if stegodons had outnumbered elephants during late

Pleistocene in China, where forested environment has been predominated. I have examined published data of southern Chinese cave fauna in attempt to see the relative abundance of stegodons and elephants.

The best snapshot of population densities of elephants and stegodons during the late Pleistocene is available from a Paleolithic site called Tong-Liang in Sichuan, China, where large number of proboscidean fossils are obtained from a fluvial bed dated at 21550±310 bp (Zhang *et al.* 1982). Pollens and plants macrofossils obtained from the bed suggest the vegetation was similar to present-day subtropical damp forest of Sichuan. In this habitat, *Stegodon* outnumbered *Elephas*. Dominance of *Stegodon* over *Elephas* observed in Tong-Liang is impressive but a piece of data from only one locality is not sufficient to show the general tendency of stegodons and elephants densities in the late Pleistocene of China.

2.2 Other localities in southern China

I examined about 130 papers on localities where *Stegodon* and *Elephas* occur separately or co-occur, to learn if the tendency seen in Tong-liang is generally the same throughout the late Pleistocene of China. Ideally, census study must be based on the number of specimens obtained from study area, but, except for Tong-liang, most of Chinese papers do not document the number of specimens found in localities. Instead of the number of specimens, that of assemblages is counted here. If assemblages from a locality are clearly distinguished bed by bed in literatures, they are counted separately.

Taxonomic status of Chinese Pleistocene proboscideans must be clarified, prior to the examination of the proboscidean localities in South China. Ideally, taxa compared must be identified at specific level. However, most of the reports on excavation in China are without the description of the specimens and the specific status of fossil taxa is not always clear. Thus, we employed only the generic name in our analysis.

In order to select reliable data for the analysis, the description of the stratigraphy of the locality in the literature is examined. More than half of the reports are found not detailed in the description of the stratigraphy. Such published data are omitted together with obviously contaminated assemblage from the data set.

Late middle and late Pleistocene assemblages are selected using radiometric dating data and an index fossil. In South China, ^{14}C and uranium series methods have been done only on the site from where important hominid fossils or Paleolithic tools have been excavated. Thus, limited number of the site will be remained in the data set if only the radiometric dating is used for the selection of the localities. Other means to determine the geological age of the assemblages is necessary. *Crocuta crocuta ultima* (Matsumoto 1915) is employed here as an index fossil, to include more assemblages in our analysis, in addition to the radiometric dates. Recent reexamination of several U-series dating of oldest localities of *Crocuta crocuta ultima* in South China suggests that those localities are geologically much older (ca. 240 ka) than previously thought (Shen & Jin 1991). The last record of this species was reported from in Shengxian Cave at Lishui, Jiangsu (11,200±1000 bp.) (Ma & Tang 1992). Thus, the possible geological ages of assemblages analyzed here are scattered between ca. 240 ka and ca. 10 ka.

The assemblages formed under closed habitat are selected because concern here is whether forested environment is more favored by *Elephas* or *Stegodon*. In order to exclude the fossil assemblage formed under temperate or steppe vegetation from the data set, the assemblages containing genus *Equus*, which is regarded here as an indicator of open habitat, were omitted from the data set. Consequently, the list contains only the assemblages from woodland and forest environment. Another list that includes assemblage presumably came from densely forested area is also made. *Ailuropoda, Pongo* and *Hylobates* are considered here as indicators of densely forested area since they are found today in such area (Corbet & Hill 1992). Using those three taxa as indicators of denser forest, second list was made.

3. RESULTS

Two lists obtained through above procedure were subjected to a statistical test. McNemar's test was carried out here because same assemblages are counted two times in order to obtain the ratio between number of assemblages containing *Elephas* and those containing *Stegodon*. The null hypothesis is that the frequencies of the assemblages containing *Stegodon* and those containing *Elephas* are equal in both lists. I employed binomial distribution for the calculation of the one-tailed probability of the data because when samples are small, an “exact” binomial test is recommended (Sokal & Rholf 1995). Number of assemblages containing *Stegodon* is significantly greater than that containing *Elephas* in both lists. This result may suggest that subtropical and tropical forests in south China during the period between ca. 230 ka to ca. 10 ka was more favored by *Stegodon* than by *Elephas*.

4. DISCUSSION

4.1 Implication of the Generalist vs. Specialist hypothesis

Until detailed census study of Pleistocene proboscideans from China has been done together with additional radiometric studies, it may be premature to draw conclusion on the relative densities of stegodons and elephants. Nevertheless, the above result for south China in general, and for the Paleolithic site Tong-Liang in Sichuan in particular seems to suggest that stegodons outnumbered elephants during late Pleistocene and the former taxon did not decline until the very end of Pleistocene at least in forested areas of southern China. This result has implications for both generalist vs. specialist hypothesis and extinction pattern of stegodons in East Asia.

According to Shoshani (1989, 1992), data from *Mammuthus* vs. *Mammut* in North America supports generalist vs. specialist hypothesis. Primitive taxa *Mammut* outnumbered *Mammuthus* in diverse habitat. Likewise, in southern Chinese case, primitive taxa stegodons outnumbered derived taxa *Elephas* in diverse forest habitat. Thus both cases in North America and China seem to support the generalist vs. specialist hypothesis.

However, there remain some problems concerning the distinction between generalist and specialist in extinct taxa. Shoshani (1989, 1992) suggested that *Mammuthus* is a specialized grazer whereas *Mammut* is a primitive browser. However, there still remain uncertainties concerning feeding habit of American mastodons. American mastodons have traditionally been considered to be typical browsers, because of their primitive molar structure. Following this traditional view, Haynes (1991) considered American mastodons selective feeder who travel between clumps of dicotyledonous plants. However, Gobetz & Bozarth (2001) suggested that mammutid fed on grass as well as browse based on the analysis of opal phytoliths in tooth calculus of *Mammut* molars. Intestinal contents and coprolite from mastodont remains also suggest a mixture of browsing and grazing habits (Lepper *et al.* 1991, Harington *et al.* 1993). Thus, those recently obtained data suggest that American mastodons were mixed feeder.

The above arguments suggest exact diet of the American mastodons is still hard to be determined and the primitive nature of molar structure alone can not specify specialist or generalist nature of the extinct animal. Obviously, we still need some means other than molar structure to estimate food selection even in the case of well studied American mastodon, much more in the case of stegodons. Structural difference between stegodons and elephants in molar is less than that between mastodons and mammoths, and what is even worse, there has been nearly no report on plant material associated with stegodons remains from southern Chinese cave fauna. Until we obtain reliable picture of feeding habits of stegodons, it seems to be quite premature to consider that southern Chinese case fits generalist vs. specialist hypothesis.

4.2 Implication on extinction pattern of stegodons

Present result cast doubt on my previous idea that most of stegodons already declined before the late Pleistocene (Saegusa 1996). My previous idea on the extinction pattern of stegodons is provably very biased because when I prepared a chronological range chart of stegodons, I employed only the fossil records accompanied with radiometric data and the magnetostratigraphy of continuous geological sections. Late survival of stegodons into the very end of the late Pleistocene may not be specific to southern China but also in other areas in Asia. Recent radiometric study done on Ngangdong, central Java (Swisher *et al*. 1996) suggests that stegodons still survived until the very end of Pleistocene in Java. Therefore, chronological range of stegodons and its abundance during Pleistocene must be revised not only in China but also India or Indonesia, based on published data, which are not used in my previous revision of stegodons.

5. CONCLUSION

Based on literature survey on ca. 180 localities in southern China, a data set of stegodons and elephants is constructed, to learn if stegodon outnumber elephants in the late Pleistocene fauna of China. McNemar's test on this data set suggests that stegodon outnumber elephants in the late Pleistocene fauna of China. This results seem to support the Generalist vs. Specialist hypothesis proposed by Shoshani (1992). Note, however, that because of the complexities in feeding mechanisms in *Stegodon* and *Elephas*, the definitions of the terms “grazer” and “browser” do not necessary help to distinguish between generalist and specialist taxa. Detailed reconstruction of feeding habits of stegodons is necessary for the evaluation of the present results. Present result also suggests late survival of stegodons into the very end of the late Pleistocene may not be specific, to southern China but also in other areas in Asia.

6. REFERENCES

Corbet, G.B. & Hill, J.E. 1992. *The Mammals of the Indomalayan Region: A Systematic Review*. Natural History Museum Publications, Oxford University Press, New York.

Gobetz, K.E. & Bozarth, S.R. 2001. Implications for Late Pleistocene mastodon diet from opal phytoliths in tooth calculus. *Quaternary Research,* 55: 115-122.

Harington, D.R., Grant, D.R., & Mott R.J. 1993. The Hillsborough, New Brunswick, mastodon and comments on other Pleistocene mastodon fossil from Nova Scotia. *Canadian Journal of Earth Science* 30: 1242-1253.

Haynes, G. 1991. *Mammoth, Mastodonts, & Elephants. Biology, Behavior, and the Fossil Record*. New York: Cambridge University Press.

Lepper, B.T., Frolking, T.A., Fisher, D.C., Goldstein, G., Sanger, J.E., Wymer, D.A., Oden III, J.G. & Hooge, P.E. 1991. Intestinal contents of a Late Pleistocene mastodont from midcontinental North America. *Quaternary Research,* 36: 120-125

Ma, A. & Tang, H. 1992. On discovery and significance of a Holocene Ailuropoda-Stegodon fauna from Jinhua, Zhejinag. V*ertebrata PalAsiatica* 30: 295-312.

Saegusa, H. 1996. Stegodontidae: Evolutionary relationships. In J. Shoshani & P. Tassy (eds.), *The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives*: 178-190. Oxford: Oxford Universty Press.

Shen, G. & Jin, L. 1991. U-series age of Yanhui Cave, the site of Tongzi Man. *Acta Anthropologica Sinica,* 10: 65-72.

Shoshani, J. 1989. A report on the Shelton Mastodon Site and a discussion of the numbers of mastodons and mammoths in Michigan. *Michigan Acadecian,* 21: 115-132.

Shoshani, J. 1992. Ecology and taxonomy: a new approach, using *Heterohyrax* vs. *Procavia* as a case study. *Israel Journal of Zoology,* 38: 399-416.

Sokal, R.R. & Rholf, F.J. 1995. *Biometry*. 3rd ed. New York: W.H. Freeman and Company.

Swisher, C.C., Rink, W.J., Anton, S.C., Schwarcz, H.P., Curtis, G.H., Suprijo, A. & Wadiasmoro 1996. Latest Homo erectus of Java: Potential Contemporaneity with Homo sapiens in Southeast Asia. *Science* 274: 1870-1874.

Takahashi, K., Namatsu, K. 2000. Origin of the Japanese Proboscidea in the Plio-Pleistocene. *Earth Science* (Chikyu Kagaku), 54: 257-267.

Zhang, S., Wu, Y., Yu, Q., Li, X. & Yang, X. 1982. Discussion of natural environment of Palaeolithic site of Tong-Liang. (Investigation of the natural environment of the Tongliang Paleolithic site). *Vertebrata Palasiatica*, 20: 165-179.

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Of Mice, Men and Elephants - lithic tools and faunal remains at the Late Pleistocene site of Masangano (Rwanda)

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SUMMARY: The deposits at Masangano record sediment accumulation outside the proper rift valley. Their fossil content comprises pollen, indicating a more savannah-type climate as well as molluscs, fish remains, reptiles and small mammals, typical for a tropical mountain forest. In contrast, the taphocoenosis of the hanging layer is dominated by fossils of large animals, preserved by a travertine superposition and accompanied by many Stone Age artefacts of different lithic industries, indicating a butchering place and an artefact site as well. Considering the hydrographic situation, the sediments at Masangano and at a few neighbouring localities are the key to understanding the assumed turnover of the drainage system during the rift shoulder development as well as the climatic situation. For this part of Central Africa, they shed light on the living conditions of the flora and fauna including modern *Homo sapiens* during the late Pleistocene.

1. INTRODUCTION

In the central part of the western branch of the East African Rift system, only the large rift lakes yield larger quantities of Tertiary and Quaternary sediment, which contribute to the reconstruction of the rift's development.

Outside the valley, no such deposits have been reported before. However, the Masangano sediments (re)discovered by the Landessammlung für Naturkunde Rheinland-Pfalz in 1994 do record sediment accumulation within that area during the Late Pleistocene.

2. GEOLOGY

The geology of Rwanda is mainly characterised by two formations of Precambrian rocks. The first of these consists of mostly weakly metamorphically superimposed, folded sediment series running from North to the South, the second of granite complexes with subordinate pegmatites thrust up in two phases (1300 million years and 900 million years BC) during the "Orogenese Kibarienne". The primary ore deposits of Rwanda are connected with the latter formation.

In the west of Rwanda, subordinate Tertiary rocks occur. They are only found in connection with the western branch of the East African rift system, which is also connected with the rise of the Virunga volcanoes.

In the Masangano region, 45 km south of the volcanoes, this results in the occurrence of Precambrian rocks with thick quartzite veins and a lava stream which runs from the Visoke Volcano almost to the mouth of the Mukungwa.

3. SEDIMENTS

At Masangano, a sediment body of ca. 25 m thickness on the eastern bank of the steep terrace valley has been cut open by the Mukungwa river (Fig. 1).

For the sake of simplicity, the sediments can be organised into two main formations. The first of these, which was most important for the first investigations (Vansina 1958, Bertossa & Neugebauer 1969), is the hanging layer with a travertine superposition of ca. 3.5 m thickness.

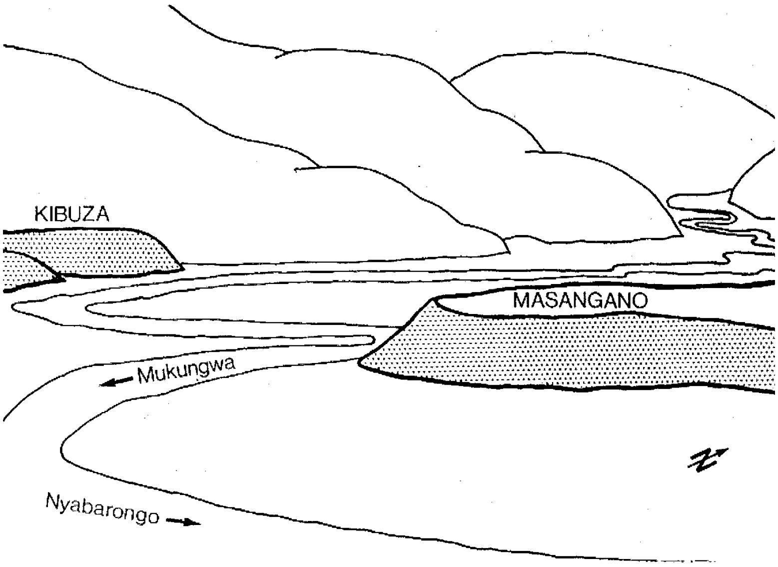

Fig.1 - Masangano and river terraces. View from SE upstream Mukungwa valley.

It is being exploited for the production of lime and contains fossils of large mammals and archaeological objects.

Below that, there is an alternate stratification of cross-bedded lacustrine-fluviatile sands and silt, which continue below the modern water level of the Mukungwa, which today flows from the N to S. From these sediments, a former direction of flow from S to N can be determined.

The portion of silty and clayish layers increases markedly towards the subjacent bed. Coarse, nearly pure quartz sands, dark micaceous fine sands and silts with some brown and blue-grey clay layers alternate; a pattern of coarse and fine layers (coarse sands at the base, silt at the top) can be observed.

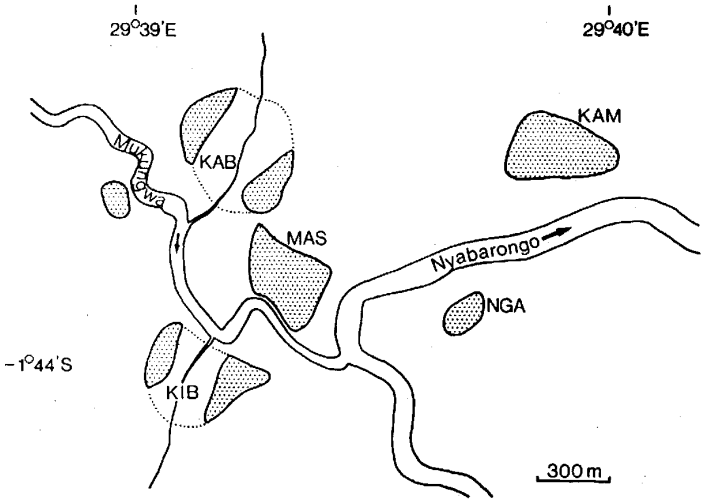

Fig.2 - Sediments in the Masangano area (MAS = Masangano).

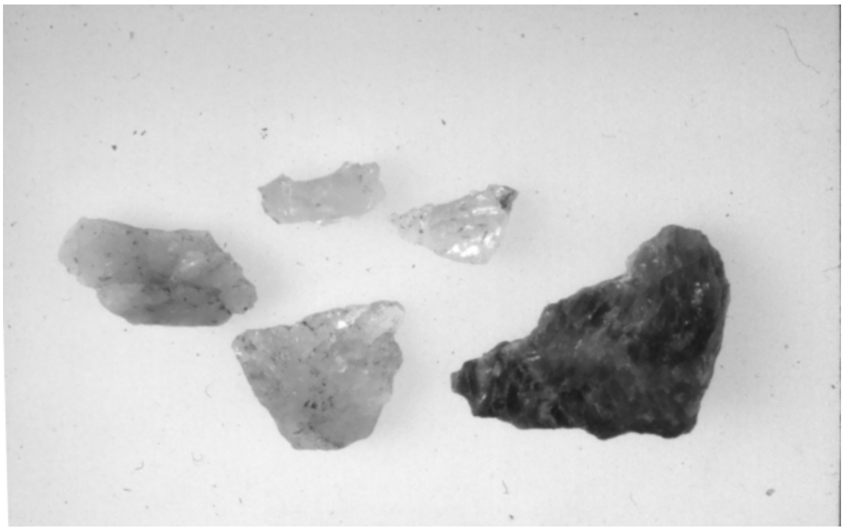

Fig.3 - Flakes and Tools.

Prospecting in the region led to the discovery of further sediment bodies (Fig. 2). However, these, lacking an travertine superposition, are not as well preserved as those of Masangano (Schmidt 1996).

4. Masangano Fossils and Artefacts

In the lower stratigraphic sequence with a thickness of ca. 20 m, which continues under the water level of the Mukungwa river, pollen could be found indicating a savannah-type climate. The mollusc finds include remains of Ancylidae and Sphaeriidae among others. Numerous remains of fishes, reptiles and small mammals prove the changing velocity of flow in a lacustrine-fluviatile state. The teeth and jaw fragments indicate the existence of at least three Muridae. Specifically, remains of *Otomys* sp. and *Thamnomys* sp., both indicating a tropical mountain forest or mountain savannah, as well as remains of cf. *Mastomys* sp. have been discovered. The exact species determination is in process.

The stratigraphic sequence of the hanging layer following above is characterised by the massive travertine superposition. On the surface, Vansina (1958) found fairly recent, “modern” pottery remains with an age of ca. 2000 years. Directly below, he discovered sherds and quartz microliths of the Wilton industry, typical of savannah environments. Finally, there is a further horizon, containing lithic tools of quartzite, quartz and slaty material, which he identified as belonging to an earlier culture, the Tshitolien culture of the forests of Zaire and Angola (Fig. 3). These are accompanied by tools and flakes of Later Stone Age industries, which Vansina describes as recalling the Levallois and Acheulean techniques. One spectacular archaeological find of Vansina was a polished piece of quartz from a stone bowl. It is unknown if or where this piece is preserved.

In this horizon, there are also numerous fragments of large mammals, partly embedded in the travertine, partly deposited directly below it. These remains include *Hippopotamus* sp., *Syncerus* sp., *Hylochoerus* sp., *Lutra* sp., *Tragelaphus* sp. and *Loxodonta* sp. (Fig. 4). The composition of these fossils leads to the supposition that the Masangano region was a transition area between savannah and forest (Schmidt & Neuffer 1995).

5. Conclusion

The tools and flakes from the upper layer of the Masangano sediment body, produced out of the local quartz, which was not very suitable, but readily available, point to an artefact site.

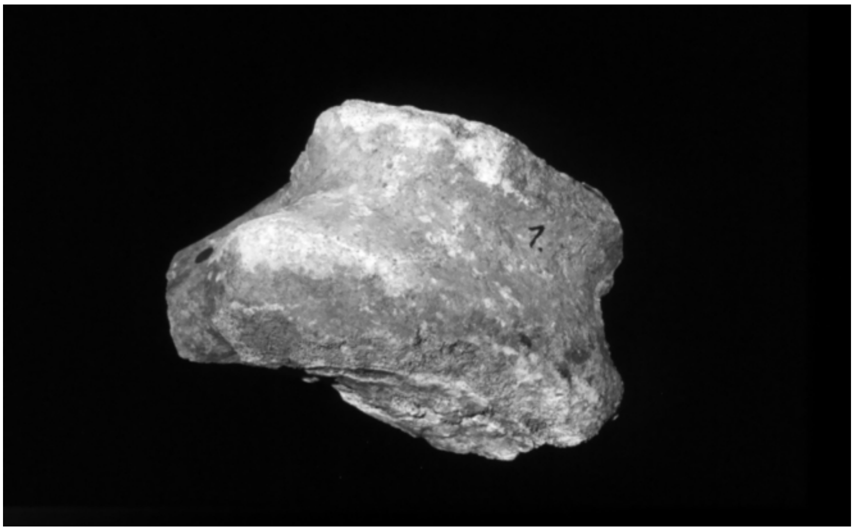
Fig.4 - *Loxodonta* sp. (femur fragment)

At the same time, the abundance of remains of large mammals suggest that it could have been a butchering site as well. It is the fact that both archaeological and palaeontological finds can be made side by side that makes the Masangano sediment such an important site for both disciplines.

The results of Vansina and our own research (Schmidt 2001, in press) illustrate the climate and the living conditions at this place in the Pleistocene.

Considering the hydrographic situation, the sands can be attributed to a relatively short-termed local depocentre in the drowned "Paleo"-Nyabarongo (and modern Mukungwa) valley. Therefore, they are the key to understanding the assumed turnover of the drainage system during the rift shoulder developments (Holzförster, Schmidt & Neuffer, in press).

Further sediment bodies in the region and the terrace formations of the Mukungwa valley will play an important role in the interpretation of the rift shoulder development.

6. Outlook

Further in-depth research at the fossil site, the terraces and the sediments is planned. In co-operation with our partners from the rwandese Geological Service, the National Museum Butare / Rwanda and with F. Holzförster from the Rhodes University Grahamstown / South Africa, detailed sedimentological and petrographic analyses, further extrication, identification and dating of archaeological and palaeontological material as well as geomorphological research on valley formation will continue.

In this, the goal is not only to increase knowledge of the Masangano region itself, but to gain more information about the rift formation, the rise of the Virunga volcanoes and the living conditions of the flora and fauna in Central Africa during the Pleistocene.

7. References

Bertossa, A. & Neugebauer, W. 1969. Le gisement de calcaire de Masangano. *Bull. serv. géol.*, 5: 5-12. Ruhengeri.

Holzförster, F., Schmidt, U. & Neuffer, Fr.-O. in press 2001. Die pleistozänen Sande von Masangano (NWRuanda, Zentralafrika) und ihr Bezug zur Entwicklung des Kivu-Nile Rifts: Eine Bestandsaufnahme. *Mz. naturw. Archiv*, 39. Mainz.

Schmidt, U. 1996. Sedimente und Fossilien des Jungpleistozäns im nördlichen Ruanda. *Zbl. Geol. Paläont*. Teil I. Heft, 7/8: 849-857. Stuttgart.

Schmidt, U. in press. The Pleistocene fossil site of Masangano in NRwanda. *Palaeoecology of Africa,* 27. Rotterdam.

Schmidt, U. & Neuffer, Fr.-O. 1995. Zur Hydrogeographie Ruandas – Die pleistozänen Sedimente von Masangano. *Zbl. Geol. Paläont*. Teil I, Heft, 3/4: 487-494. Stuttgart.

Vansina, J. 1958. Fouilles á Masangano. Pris de date. Folia scient. *Africae centr.,* 4(3): 70.

The vegetation and mammoth distribution during the second half of the Late Pleistocene on the Russian Plain (33-17 ka)

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SUMMARY: The paleofloristic materials from 96 sections of the Russian Plain for the Briansk time and the Late Valdai have been united in a palynologic database. Analysis of the electronic maps made it possible to study temporal dynamics of distribution of indicator species of plants during the second half of the Late Pleistocene. The coenoses for the Briansk Interstade and Late Valdai glaciation were reconstructed from the north to the south of the Russian Plain. The predominance of open coenoses (the periglacial steppe and forest-steppe formations) during the Middle and Late Valdai on the territory of the Russian Plain was favorable for mammoths which mostly fed on forbs, leaves and branches of different bushes.

1. THE BRIANSK INTERSTADE - LATE VALDAI GLACIATION VEGETATION DYNAMICS

1.1 Introduction

The findings of mammoth remains attributed to the second half of the Late Pleistocene (33-17 ka) are widespread on the Russian Plain from the Pechora River basin to the Dniester River middle reaches (Markova *et al.* 1995). It is important to elucidate the main characteristics of paleovegetation, surrounding the mammoth, because the mammoth (*Mammuthus primigenius*) was one of major Late Pleistocene representatives of large herbivorous.

Studies of V.V. Ukraintseva (1991) showed on the principal composition of mammoth food including mainly forbs, leaves and branches of different bushes. In the cold seasons mammoth used the undersnow plants.

1.2 Materials and methods

To the present time considerable palynological material was gathered. It permits to trace the main ways of paleovegetation development during the Briansk Interstade (33-24 ka) and the Late Valdai glaciation in the Russian Plain (<24-17 ka).

The available palynological (52 sites for the Briansk time and 64 sites for the Late Valdai) material has been summarized in a database and was formatted in the ARC/INFO and ARC/VIEW cartographic software. Electronic map series of different plant species that describe certain vegetative coenoses, and a series of maps of different plant communities determining a landscape as a whole, were constructed.

1.3 Vegetation dynamics and climatic cycles

The Briansk Interstade is the most significant warming of the last glacial epoch preceding the Late Valdai glaciation. The tundra and forest-tundra coenoses were considerably wider represented in the landscape structure than nowadays. The tundra and forest-tundra elements had a wide distribution in the Russian Plain. Spores and pollen of Arctic and hypoarctic species such as *Armeria*, *Dryas*, *Rubus chamaemorus*, *Alnaster fruticosus*, *Selaginella selaginoides*, and *Lycopodium apressum*, reached 53-54° N.

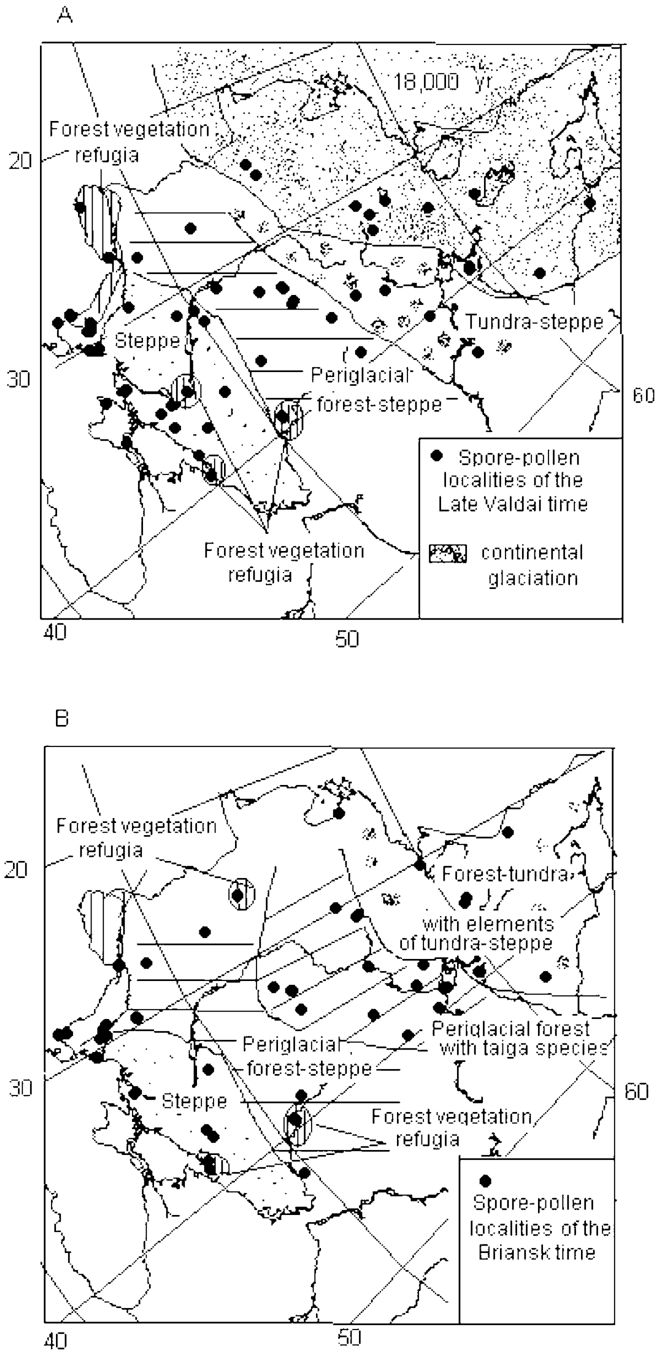

Fig. 1 - Scheme of reconstruction of vegetative coenoses:
A- during the Late Valdai glacial maximum (24-17 ka);
B- during the Briansk Interstad (33-25 ka).

So the southern border of these taxa ranges was shifted approximately at 1200 km southward. Forest-tundra plants *Alnaster fruticosus, Selaginella selaginoides,* and *Betula nana,* were found in the southwestern Russian Plain and in Carpathians. This indicates an expansion of areas of microthermic plants in these regions. Further expansion of the Arctic flora to the south, for ~ 60 up to 47° N (or more than at 600 km) occurred in the Late Valdai glaciation (Markova, Simakova, 1998). Northern taiga species ranges (*Picea, Abies, Larix, Pinus sibirica*) considerably expanded to the south, however the continious taiga zone did not exist. Probably it was the territories associated with highly dissected regions of the Russian Plain.

The presence of small amount of broad-leaved species in the forest communities have been established in the Neman, Valdai, and Moscow Uplands during Briansk Interstade. Broad-leaved plants occurred in more appreciable quantities in the Dniester River basin, in the Podol and the Middle Russian Uplands, in the Donetsky Ridge, the Carpathians, and Crimea.

In the Late Valdai time a further reduction of their ranges occurred. However, refugia of forest coenoses with broad-leaved species remained in the Dniester and Don River middle reaches, in the central part of the Russian Plain (49-51° N), in Moldova and near the Azov Sea.

In the second half of the Late Valdai the representatives of steppe phytocoenoses were widespread over the whole territory of Eastern Europe and reached 62° N. In the north of the Russian Plain steppe species were a component of tundra-steppe associations. Nowadays the similar plant associations occur fragmentary in northeast of Russia

(Eastern Siberia).

Therefore the following coenoses for the Briansk Interstade (I) and Late Valdai glaciation (II) were reconstructed from the north to the south of the Russian Plain (Fig. 1).

- I (33-22 ka)

1. Forest-tundra : combination of tundra and steppe vegetative communities with pine-birch light forest

2. Periglacial forest tundra-steppe located between 54° and 59° N: combination of birch-pine and spruce forest areas with meadow steppe formations, tundra communities and steppe halophyte species.

3. Periglacial forest-steppe: meadow steppes with pine-birch forest islands , with insignificant quantity of broad-leaved trees (54° N - 50°N).

4. Periglacial steppe: original forb steppe and forb steppe with *Chenopodiaceae* situated to the south of 49°-50° N.

5. Forest refugee: birch-pine and spruce forest with broad-leaved trees.

- II (24-17 ka)

1. Tundra with elements of forest-tundra and tundra-steppe.

2. 2. Periglacial forest-steppe:

a) meadow steppe with areas of birch-pine and spruce forest and with tundra-steppe communities occurred in the Russian Plain between 56° and 59° N;

b) association of meadow steppe, tundra-steppe and pine-birch light forest.

3. Periglacial steppe: forb- steppes were widespread to the south of 51° N.

3. Forest refugee: birch-pine and spruce forest with broad-leaved trees

2. CONCLUSIONS

The individualistic reorganization of communities in response to environmental changes is important for the understanding of the history of development of biological communities (Graham & Grimm 1990). The reconstructed biogeographical provinces of Russian Plain show that in this time the analogues of modern natural zones on the territory of the Russian Plain were absent. Late Pleistocene landscapes indicate the moderate cold climate of the Briansk Interstade and the cold and continental climate during the Late Valdai glaciation. Forest coenoses occurred fragmentary. They were mainly associated with the dissected territories with variable local habitats (uplands, mountain systems) and with the gullied relief. The distinctions between vegetative provinces were smoothed. The subarctic and steppe plants were represented practically everywhere. However, in contrast to the natural conditions of the Briansk time the Late Valdai maximum in the Russian Plain was characterized by a wider distribution of different types of periglacial forest-steppe and tundra-steppe landscapes. So the predominance of open coenoses (the periglacial steppe and forest-steppe formations) during the Middle and Late Valdai on the territory of the Russian Plain was favorable for mammoths which principal food includes forbs, leaves and branches of different bushes.

3. ACKNOWLEDGEMENTS

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4. REFERENCES

Graham, R.W. & Grimm, E.C. 1990. Effects of Global Climate Change on the Patterns of Terrestrial Biological Communities. *Trends in Ecology and Evolution*. 5.9: 289-292.

Markova, A.K. & Simakova, A.N. 1998 Distribution of mammals'and plants'indicator species at the second part of Valdai Glaciation. Izvestia RAS, *Seria geograficheskaia,* 3: 49-61.

Markova, A.K., Smirnov, N.G., Kozharinov, A.V., Kazantseva, N.E., Simakova, A.N., Kitaev, L.M. 1995. Late Pleistocene Distribution and Diversty of Mammals in Northern Eurasia (Paleofauna Database). *Paleontologia e Evolucio*'. 28-29: 5-143.

Ukraintseva, V.V. 1991. About the reasons of mammoth and its companions extinction. *Paleoteriologicheskie issledovania fauny SSSR*, 238: 167-184.

Gravettian mammoth bone deposits in Moravia

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SUMMARY: In addition to the description of 8 Moravian sites associated with mammoth bone deposits (MBD), this paper discusses the various hypotheses explaining their formation either as natural or human-influenced. Recent research records a variability in size of the deposits, but uniformity in chronology (30-20 ka), cultural association (Gravettian/Pavlovian) and spatial patterning (location along the main rivers).

1. INTRODUCTION

The mammoth bone deposits (MBD), in association with the large Gravettian settlements, are located along the main river system of the Moravian corridor (Fig. 1). Over the 120 years of research, several competing hypotheses aimed to explain these accu-mulations as a part of the Gravettian resource e-xploitation system. The various authors underlined either specialized mammoth hunting or mammoth scavenging, and relationship to other resources such as reindeer hunting, net-hunting of smaller game or plant gathering. Specifically, one of the alternatives explains the mammoth bone deposits as natural death sites, secondarily exploited by humans for bone, ivory, skins or frozen meat. Other alternatives view them as a result of specialized mammoth hunting: as kill-sites, areas of refuse or storage. There are also combined explanations, taking into account both natural formative processes and human activity.

Chronologically, MBD formation is related to one cultural unit only, the Gravettian (30-20 ky). Poten-tially, this may be one of the indirect arguments for a human origin of these deposits. MBD termination, on the other hand, correlates with the climatic dete-rioration around the last glacial maximum.

Spatially, MBD follow the type of landscape prefe-red both by mammoths and hunters (the “Gravettian landscape”, Fig. 1), i.e. locations on slopes, in low and middle altitudes, within the main river valleys of Moravia: Dyje (Dolní Věstonice, Pavlov, Milovice), Morava (Jarošov, Spytihněv, Boršice?), and Bečva (Předmostí). On the Dyje river in southern Moravia, these deposits are also related to smaller side valleys and gullies (Fig. 2). Such terrain situations, optimal for development of hunting strategies, could provide another indirect argument for human origin of the MBD.

A variability is being recorded among the individual MBD, concerning size, spatial relationship to adja-cent settlements, occurrence of other animals than mammoths, and the archaeological context (charcoal layers, rare lithic artifacts). Some of these locations also suffered from postdepositional processes, na-mely landsliding and erosion, or from industrial exploitation of loess and bones.

2. THE BONE DEPOSITS

2.1 Dolní Věstonice I

Several MBD (named “*kjökkenmöddings*”) were discovered by K. Absolon, especially in upper part of this large and complex settlement. One of them, because of its circular shape, was later interpreted by B. Klíma as basement of a dwelling structure. Ho-wever the largest MBD was excavated by B.Klíma next to the upper part of the settlement in a shallow, partly watered depression, located longitudinally along the slope, about 45 m long and 12 m wide.

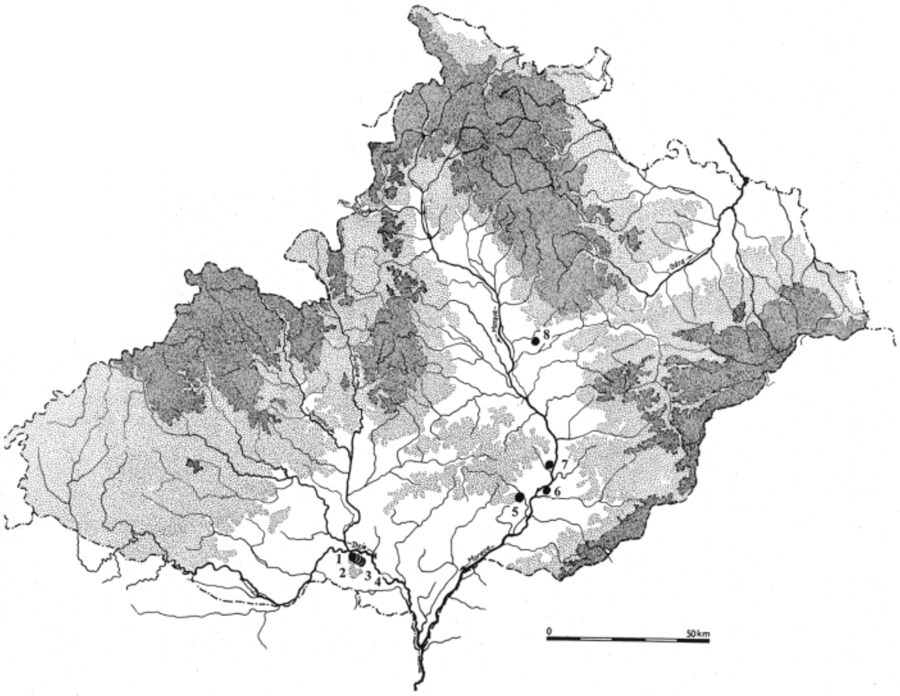

Fig.1 - Location of the MBD sites in Moravia. 1-2: Dolní Věstonice I-II, 3: Pavlov I, 4: Milovice I, 5: Boršice, 6: Jarošov, 7: Spytihněv, 8: Předmostí I

Besides mammoths, this bone deposit also contained few remains of horse, wolf, reindeer and hare (Absolon 1938, Klíma 1969, n.d.).

2.2 Dolní Věstonice II

This is a large, spatially and chronologically structu-red settlement, following longitudinally the eastern margin of a side valley, about 500 m long. Part of a MBD, measuring 10 x 10 m and located in fluviatile sands (with water snails), was excavated by J. Svo-boda in the upper part of the gorge (Fig. 3). Addi-tional mammoth bones were scattered in lower parts of the gorge as well. It is not excluded that large portions of the valley floor, together with bones (?), are eroded (Svoboda, ed. 1991, West 2001).

2.3 Pavlov I

This large and complex settlement, excavated by B.Klíma, provided only smaller and spatially re-stricted mammoth bone accumulations inside the settled area, but an MBD was absent. If we would expect it downslope, at the bottom of an actually active side valley, it could be removed by land-sliding and/or erosion by the brook (Svoboda, ed. 1997).

2.4 Milovice I

This site is located in the terminal part of a large side valley, about 2000 m long. Two MBD (larger than the adjacent settled areas above them) were located on a slope, about 1500 m from the valley mouth. Besides mammoths, there is an admixture of horse, reindeer and wolf. Inside the settled area above, a circular mammoth bone accumulation was found by M. Oliva, and interpreted as a dwelling (Oliva 1988).

2.5 Boršice

From this disturbed settlement, only a “miniature” MBD (with admixture of wolf and reindeer), about 1 m in diameter, has been

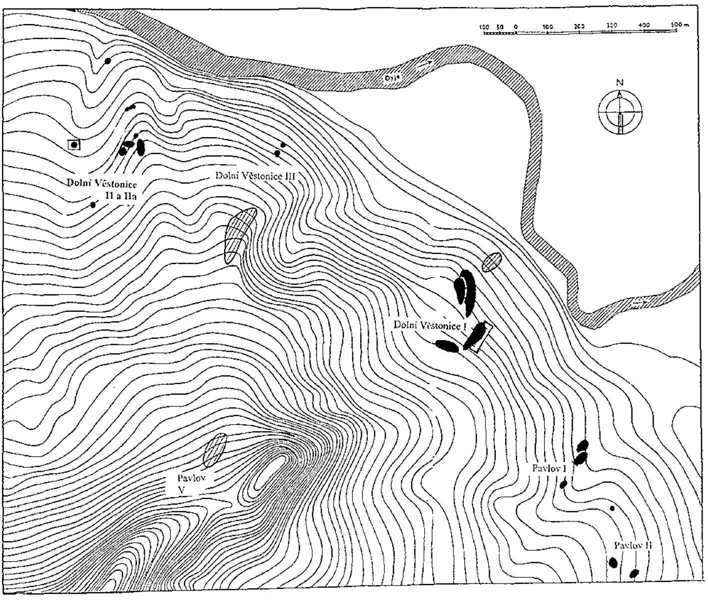

Fig.2 - Detailed plan of Upper Paleolithic settlement in the Dolní Věstonice-Pavlov microregion. Excavated MBD, at Dolní Věstonice I and II, are indicated by oblong areas.

recorded by B. Klíma. It is mentioned here becase one may suspect its originally larger extension.

2.6 *Jarošov II*

A longitudinal deposit of mammoth bones (with some of rhinoceros and horse), about 6 m in length and 3 m wide, has been excavated by R. Procházka, and supplemented by another 3 m by L. Seitl and K. Valoch (1998). Later, an adjacent settlement was discovered about 200 m away on the same slope, and excavated by P. Škrdla.

2.7 *Spytihněv*

Basing on old reports by V. Hrubý, a “pit”, 15 m in diameter, filled with mammoth bones, has

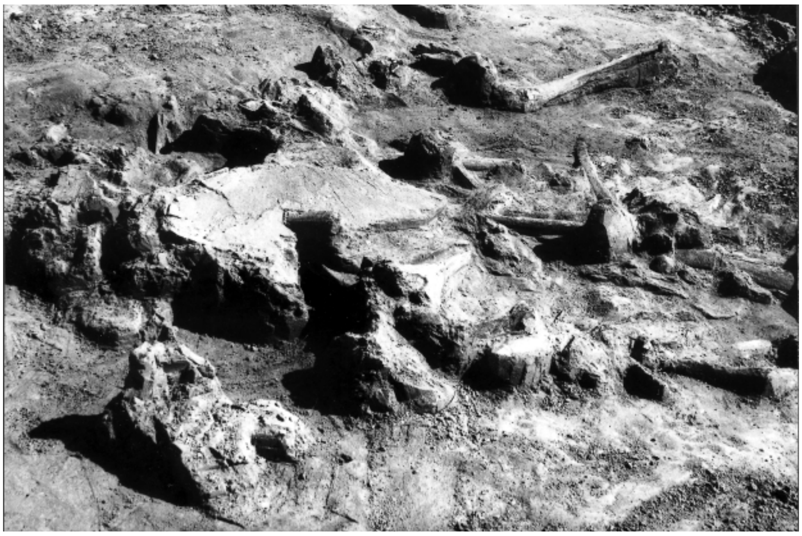

Fig.3 - Example of a mammoth bone deposit.

been found on the level of the Morava river valley. Following P. Škrdla, the deposit has been removed from the slopes above by land-sliding. A possible settlement location lied nearby.

2.8 *Předmostí I*

Original picture of this classical site is largely de-formed by the industrial exploitation of limestone, loess and bones, and the lack of spatial documenta-tion from earlier excavations. However, the bone accumulation was so large that it was recorded as early as the 16th century, as “giant bones below the Skalka rock”. This deposit was most probably loca-ted in the original depression with mineral water sources. During the early excavations to the north and west of Skalka, other MBD were recorded inside the settled areas or directly adjacent to them. In addition, several groups of selected mammoth bones, deposited after sorts, were recorded by J. Wankel, K.J. Maška and M. Kříž (Absolon & Klíma 1977).

3. REFERENCES

Absolon, K. 1938. *Die Erforschung der diluvialen Mammutjäger–Station von Unter–Wisternitz in Mähren. Arbeitsbericht über das zweite Jahr 1925*. Brünn.

Absolon, K. & Klíma, B. 1977. *Předmostí. Ein Mammutjägerplatz in Mähren*. Fontes Archaeologiae Moraviae 8, Brno.

Klíma, B. 1969. Die grosse Anhäufung von Mammutknochen in Dolní Věstonice. *Acta Sc. Nat. Brno* III/6. Praha.

Klíma, B. n.d. *Die Kjökkenmöddinge Nr. 5-8 von Dolní Věstonice*. Manuscript for publication.

Oliva, M. 1988. A Gravettian site with mammoth-bone dwelling in Milovice (Southern Moravia). *Anthropologie*, 26: 105-112.

Seitl, L. & Valoch, K. 1998. Stanice gravettienských lovců mamutů v Jarošově. *Acta Musei Moraviae, Sc. soc.*, 83: 67-81.

Svoboda, J. (ed.) 1991. *Dolní Věstonice II - western slope*. ERAUL 54, Liege.

Svoboda, J. (ed.) 1997. *Pavlov I - Northwest*. The Dolní Věstonice Studies 4, Brno.

West, D. 2001: Faunal analysis from the 1986/1987 excavation at Dolní Věstonice, western slope. *Památky archeologické.* in

Man and Mammoth in Pleistocene Siberia

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SUMMARY: Mammoth bones have been identified from many Paleolithic sites in Siberia, from the Mousterian to the Late Upper Paleolithic The paper summarizes the available data from 8 Middle and 75 Upper Paleolithic faunal assemblages. Different types of the man-mammoth associations could be deduced. These include butchering sites used for the processing of hunted animals or frozen carcasses (Tomskaia, Shikaevka II), mammoth deathsites exploited by prehistoric groups searching for bones and tusks (Volch’ia Griva, Berelekh, Shestakovo), and occasional bones, which could be procured by prehistoric man elsewhere. Use of mammoth bones and ivory for the manufacture of tools and ornaments is discussed. According to relevant evidence from the final Pleistocene occurrences, the mammoth extinction took place in different portions of Siberia in different times.

1. INTRODUCTION

The vast territory of Northern Asia has attracted the attention of the students of Pleistocene extinctions for a long time. The man-mammoth interactions in this area are of prime importance for the study of the Pleistocene adaptations to periglacial environments (Vereshchagin & Baryshnikov 1984). Research into the Pleistocene in Siberia has always been hampered by difficulties in obtaining information and linguistic barriers between the scholars of different countries. A new attempt at synthesizing such data is long overdue.

2. CHRONOLOGICAL FRAMEWORK

The earliest traces of humans in Northern Asia can be correlated with the Middle Pleistocene, *ca.* 300,000-250,000 BP (Derevianko 1997). According to the stratigraphic schemes admitted in Russia, the advent of the Middle Pleistocene was marked by the Tobol’sk interglacial followed by the maximal (Samarovo) glaciation. This maximal glaciation was followed by the Shirta interglacial and then, the Taz glaciation. Several successive faunal complexes identified in the Middle Pleistocene evidenced the appearance of woolly mammoth (*Mammuthus primigenius*) in Siberia.

The advent of the Upper Pleistocene is correlated with the beginning of Kazantseva (Eem) interglacial followed by the cold spells of the Zyrianka, correlated with the Weischselian Glacial in its broadest sense. It includes three periods. The earliest one is the Early or Lower Zyrianka, which is also called Ermakovo or Murukta glacial, the Karginsky interglacial, and the Late Zyrianka, or the Sartan, glacial. Due to the scarcity of occurrences it seems hardly possible to characterize fauna of Kazantseva, while from Zyrianka onwards the Upper Paleolithic (or Mammoth) Faunal Complex was represented by typical species such as mammoth, woolly rhino, horse, musk-ox, bison, reindeer, saiga antelope, Polar fox, lemming, etc. In Trans-Baikal this assemblage was enriched by Central Asian species as spiral horn antelope and yak (Vangengeim 1977).

Woolly mammoths (*Mammuthus primigenius*) were widely distributed in Siberia during the Upper Pleistocene, over an enormous space stretching from the Arctic Ocean to Mongolia (Orlova *et al.* 2000). Numerous discoveries of frozen mammoth remains in Northern Siberia have given us a opportunity to characterize in detail the appearance and nutrition of these giants of the Pleistocene world (Ukraintseva *et* *al.* 1996). These animals consumed mostly grasses, bushes and bark in summertime; in wintertime, they fed on dry grasses and sprouts of bushes, and coniferous trees. Mammoths inhabited mostly river valley bottoms and floodplains, migrating along rivers. Deathsites of mammoths were associated with floods; also, they accidentally died while crossing rivers and lakes by ice. However, during the second half of the Sartan, they retreated to the north. The last mammoths seem to have existed in the Polar regions (Yakutia, the Gydansky and Taimyr peninsulas) as late as 11,000 to 9600 BP. A discovery of a Holocene degenerated population of dwarf mammoth at Wrangel Island, dated *ca.* 4000 BP became a true sensation (Vartanyan *et al.* 1993).

3. Man-Mammoth interactions: spatial distribution and chronology

The paper summarizes the available data from 8 Middle and 75 Upper Paleolithic faunal assemblages associated with the mammoth remains arranged in chronological and geographical order. Only clearly stratified assemblages are included into the analysis. Unfortunately in the majority of cases we have only qualitative data at our disposal and we know next to nothing about the quantitative distributions of the mammoth remains found, age-sex ratios, etc.

The oldest man-mammoth association is presumably referred to the Middle Pleistocene as evidenced by the fauna from Ust'Izhul' in the Yenisei basin (Ovodov & Tomilova 1998). Several cave and open-air Mousterian sites located in the Altai and the Yenisei yielded mammoth remains. Among these the lower layers of the Denisova Cave and Ust'Karakol I are referred to Kazantseva, but most of the absolute dates associated with Mousterian levels are of Karginsky age, lying between 45,000 and 30,000 BP.

The Upper Paleolithic is divided into three phases – Early, Middle and Late. The earliest phase of the Upper Paleolithic has been dated at between *ca.* 34,000 to 27,000-26,000 BP. During this phase, mammoth bones are reported from all areas of concentrations of the Paleolithic localities so far known – from the Altai Mountains to the Russian Far East. The Middle phase covers the time span between 27,000-24,000 to 18,000-17,000 BP. The sites with man-mammoth associations have been discovered in Western Siberia, Yenisei, Angara and Upper Lena valleys, and from Trans-Baikal. The Late Upper Paleolithic lies from *ca.* 16,000 to 10,500 BP. During this phase, mammoth remains are mostly found in Western Siberia, Middle Yenisei valley near Krasnoyarsk, Lower Angara, and northeastern Siberia. For the same time period, the sites located in the Altai, Upper Yenisei, Upper Angara and Trans-Baikal have yielded only scarce findings, mostly represented by ivory and bone fragments and artifacts.

4. Man-Mammoth interactions: hunting, scavenging, and bone collection

West Siberia has produced evidence on mammoth processing sites. The site of Tomskaia of Early Sartan age (*ca.* 19,000 to 17,000 BP) explored at the end of the 19th century, produced a carcass of mammoth lying on charcoal lens bed bearing traces of fire. Few pieces of lithics were associated with the carcass (Kashchenko 1901). The more recent site of Shikaevka II, also in Western Siberia has revealed two mammoth skeletons lying mostly in anatomic order with scanty artifacts (Petrin 1986). It is far from clear if we are dealing with dismembering of frozen carcasses or hunted animals.

Occasionally Paleolithic man used the concentrations of animal bodies for procurement of bones and ivory. The oldest occurrence of this kind seems to be Shestakovo at Western Siberia (Derevianko *et al.* 2000) dated from *ca.* 25,500 to18,000 BP. Several cultural layers of the site evidenced successive human utilization of the deathsite located near the mineral salt sources. Among more recent sites Volch'ia Griva in the West Siberian Plain and Berelekh in Yakutia are to be mentioned. At the first site the bone-bearing layer is associated with lacustrine sediments dated to *ca.* 14,000 BP (Okladnikov *et* *al.* 1971). The second case is Berelekh, which demonstrates the spread of Paleolithic man into the Polar region (Mochanov & Fedoseeva 1996). Berelekh is near the famous mammoth deathsite, which has produced the remains of more than 150 mammoths. These are thought to have died when falling to unfrozen patches of water in the midst of an icebound river. Later the carcasses were transported by river flow to the cut-off channel where they were deposited in till sediments. The remains of the habitation site were discovered about 100 m from the deathsite. Paleontologists argue that prehistoric hunters settled near the slightly older concentration of mammoth bones, which was dated from *ca.* 13,000 to 12,000 BP (Vereshchagin 1974). Bones of reindeer, horse, hare, goose and white grouse from the cultural layer appear to have 'hunting marks' while mammoth bones seem to have been procured from the deathsite.

5. IVORY AND BONE ARTIFACTS

Mammoth ivory and bones were extensively use by the Paleolithic inhabitants of Siberia for tool and personal ornaments manufacture (Abramova 1995).

There are two cases of mammoth depictions made by Paleolithic man. The middle component of Ust'Kova located in the Angara valley yielded a schematized animal figurine made of ivory. A mammoth engraving on an ivory blade from Mal'ta is to be mentioned. For more problematic items, there is an engraved ivory fragment with thin lines depicting the profile of a mammoth. It was accidentally found on the Berelekh river 50 km upstream from the site, thus it cannot be associated with the Paleolithic site of Berelekh lying in the downstream area. Vereshchagin (1974) argues that the engraving was made on a tusk broken beforehand by ice, i.e. the fossil piece was extracted from elsewhere.

Other art objects made of ivory and mammoth bones are also mostly associated with the Middle Upper Paleolithic. No other Siberian site is comparable to Mal'ta in richness and diversity of ivory objects. Among these are series of feminine and bird statuettes. Mal'ta is also rich with sophisticated ivory and mammoth bone artifacts, including points, pins with heads, rods, buttons and needles with eyes or circular hollows, personal ornaments (ornamented plaques, beads, curved and perforated blades, bracelets, etc.). Ivory feminine statuettes and personal ornaments are also reported from Mal'ta's 'twin' site, Buret'. The site of Achinskaia produced a phallus-like ivory statuette, the so-called 'rod'.

6. CONCLUSIONS

The Siberian sites evidenced a long history of man-mammoth interactions from the Middle Paleolithic onwards. In spite of richness of habitat structures in the Siberian Paleolithic, there is practically no evidence on the use of proboscidean remains as a raw material for domestic structures. It is worthwhile to mention that we are lacking the unambiguous evidence for active mammoth hunting. What can be deduced, mostly, is the use of passive hunt with traps. But in the overwhelming majority of cases it seems that prehistoric man collected bones and tusks.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

Abramova, Z.A. 1995. *L'art paléolithique d'Europe orientale et de Sibérie*. Grenoble: Ed. Jérôme Millon.

Derevianko, A.P. (ed.), 1997. *The Paleolithic of Siberia*. Urbana: University of Illinois Press.

Derevianko, A.P., Zenin, V.N., Leshchinskiy, S.V. &. Mashchenko, E.N. 2000. Peculiarities of mammoth accumulation at Shestakovo site in West Siberia. *Archaeology, Ethnology and Anthropology of Eurasia,* 3: 42-55.

Kashchenko, N.F. 1901. Skelet mamonta so sledami upotrebleniia v pishchu sovremennym emu cheloveka. *Zapiski Akademii Nauk po fiziko-matematicheskomu otdeleniiu,* XI (7): 1-60.

Mochanov, Y.A. & Fedoseeva, S.A. 1996. Berelekh, Allakhovk Region. In F.H. West (ed.), American Beginnings. *The Prehistory and Palaeoecology of Beringia*: 218-222. Chicago: The University of Chicago Press.

Okladnikov, A.P., Grigorenko, B.G., Alexeeva ,E.V. & Volkov, I.A. 1971. Stoianka verkhnepaleoliticheskogo cheloveka Volch'ia Griva. *Materialy polevykh issledovanii Dal'nevostochnoi expeditsii,* 2: 87-131.

Orlova, L.A., Kuzmin, Y.V., Volkova, V.S. &. Zolnikova, I.D. 2000. Mamont (Mammuthus primigenius Blum.) i drevnii chelovek v Sibiri. In S.V. Markin (ed.), *Problemy rekonstruktsii klimata i prirodnoi sredy golotsena i pleistotsena Sibiri*, vyp. 2: 383-412. Novosibirsk: Institute of Archaeology and Ethnography.

Ovodov, N.D. & Tomilova, E.A. 1998. Neandertal'tsy na Enisee. In A.P. Derevianko, (ed.), *Paleoekologiia pleistotsena i kul'tury kamennogo veka Severnoi Azii i sopredel'nykh territorii,* part 1: 379-385. Novosibirsk Institute of Archaeology and Ethnography.

Petrin, V.T. 1986. *Paleoliticheskie pamiatniki Zapadno-Sibirskoi ravniny*. Novosibirsk: Nauka.

Ukraintseva, V.V., Agenbroad, L.G. &. Mead, J.I. 1996. A paleoenvironmental reconstruction of the 'Mammoth Epoch' of Siberia. In F.H. West (ed.), *American Beginnings. The Prehistory and Palaeoecology of Beringia*: 129-136. Chicago: The University of Chicago Press.

Vangengeim, E.A. 1977. *Paleontologicheskoe obosnovanie stratigrafii antropogena Severnoi Azii.* Moscow: Nauka.

Vartanyan, S.L., Garutt, V.E. &. Sher, A.V. 1993. Holocene dwarf mammoth from Wrangel Island in the Siberian Arctic. *Science,* 362: 337-340.

Vereshchagin, N.K. 1974. The mammoth 'cemeteries' of North-East Siberia. *Polar Research,* 17: 3-12

Vereshchagin N.K. & Baryshnikov, G.F. 1984. Quaternary Mammalian extinctions in Northern Eurasia. In P.S. Martin &. R.G. Klein (eds.), *Quaternary Extinctions. A Prehistoric Revolution*: 483-516. Tucson: University of Arizona Press.

The woolly mammoth (*Mammuthus primigenius*) remains from the Upper Palaeolithic site Kraków Spadzista Street (B)

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SUMMARY: Nearly all (99%) of the 9000 remains from the Kraków Spadzista Street (B) site belong to woolly mammoth. All skeletal parts are represented in the bone assemblage and come from one mammoth population. The age profile from the site is typical of a stable mammoth population. New excavations and analyses of materials indicate that 71 mammoths may have been killed at the site or died there naturally, probably not all at one time.

The Kraków Spadzista (B) site is one of many famous Mid Upper Palaeolithic (Gravettian) sites in Europe. It was discovered accidentally in the late autumn of 1967 and the excavations continue today. The Aurignacian and Gravettian sites from the Kraków Spadzista complex are located on a rocky prominence, which is isolated from the main part of Saint Bronislawa hill by a rocky cliff from the north and by a large Pleistocene depression from the east and west. After 11 years of excavations, approximately 140 sq. m of the site have been examined. At the site nearly 9000 bones and teeth of seven different species of Pleistocene mammals (Kubiak & Zakrzewska 1974; Lipecki & Wojtal 1996) and several hundred stone artefacts (Kozlowski & Sachse-Kozlowska 1974; Sobczyk 1995) were found. At Kraków Spadzista Street (B), only isolated bones or teeth (NISP= 15; MNI=7) from mammal species other than mammoth were found (Tab. 1).

Tab.1 - Number of identified specimens (NISP) and minimal number of individuals (MNI) found at the site Kraków Spadzista Street (B).

SPECIES	NISP	MNI
Canis lupus	4	1
Alopex lagopus	3	2
Ursus sp.	2	1
Equus caballus	1	1
Coelodonta antiquitatis	1	1
Mammuthus primigenius	5845	71
Rangifer tarandus	4	1
TOTAL	5860	78

Nearly all of identifiable bones belong to mammoth and all skeletal elements are represented (Tab. 2). The site yielded a large number of ribs (NISP = 2065, Minimum Number of Elements [MNE] = 715) and vertebrae (cervical, lumbar, caudal and sacrum bone; NISP = 1062, MNE = 767). Approximately 87% of all atlases (NISP = 92, MNE = 62) and 35 - 60% of expected limb bones were preserved. Numerous small bones such as sesamoids (NISP = 85) and phalanges (NISP = 172) were represented. A remarkable feature of the site is the presence of very small mammoth humeri (two) and femora (three), which could belong to mammoth foetuses. It is important to point out the presence of hyoid bones (NISP = 41; MNE = 36) and first milk teeth of woolly mammoth at Kraków Spadzista Street (B). In addition, one mammoth milk tusk was found during the excavation in 2000. It is the first record of this type of tooth in Poland. Unfortunately no large fragments of mammoth skull were represented in this mammoth bone assemblage. However, about 400 small parts (ca.10-20 cm in diameter) of skull were found. Of these fragments were 23 *basioccipitale* bones, undoubtedly belonging to 23 mammoth individuals.

Besides a large number of postcranial skeletal elements, numerous upper and lower cheek teeth (NISP = 338) of woolly mammoth are in this assemblage. Some teeth were still placed in the alveolus of maxillae and mandibles. Of 103 upper cheek teeth, seven were situated in the maxillary alveolus. Two pairs of upper teeth came from two individuals. A total of 198 lower cheek teeth were recovered at the site and of this total, 128 remained in the mandibles or refit to the alveolus or to associated teeth that were present in mandibles. Stage of tooth wear or damage to 37 teeth prohibits refitting to mandibles or maxillae and associated teeth. All of the mandibles from Kraków Spadzista Street (B) were missing the ramus portion and some of them were broken near the symphysis. The preservation of mammoth tusks was very poor. Very rarely were larger fragments of this tooth present. Only a few tusks with length from 50 - 100 cm were preserved and usually only small fragments (ca. 10-20 cm) were found.

As a result of excavations undertaken during the 1970s, a minimum number of individuals (MNI) for mammoth based on the mandibles and lower teeth was estimated at 60 (Kubiak and Zakrzewska 1974). During the 1990s, excavations at the site were continued and subsequently the estimated minimum number of individuals has been revised to 71 based on mandibles and lower cheek teeth. The eruption sequence and wear of the lower teeth were used to reconstruct the age distribution of the mammoths. The mammoth age profile from Kraków Spadzista Street (B) is characteristic for a sta-

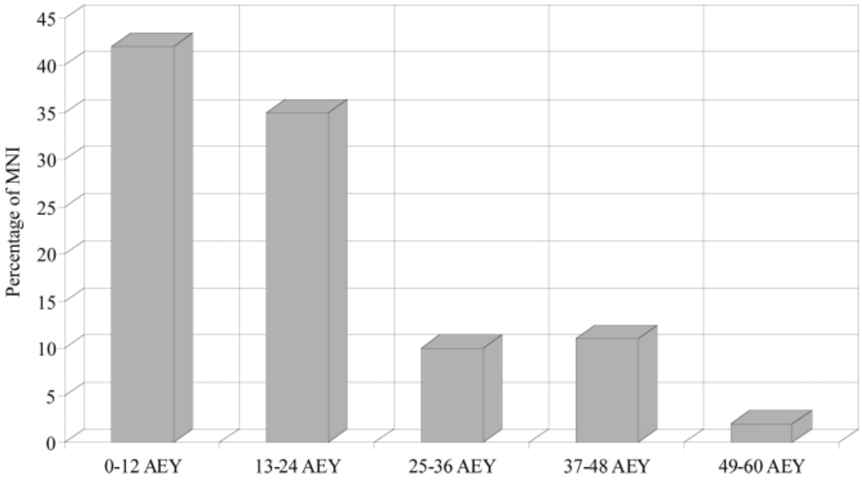

Fig.1 - Age profile of Kraków Spadzista Street (B) mammoth population. (AEY = African Elephant Years. MNI = 71).

ble population. The largest number of individuals is represented in the 0-12 years age class (30 individuals, 42 % of total MNI) and other age categories are represented in decreasing proportions (Fig. 1).

This age profile could represent time-averaged, natural (but non-selective) deaths or also abrupt, non-selective kills affecting whole herds (Haynes 1991, Soffer 1993).

In the woolly mammoth skeleton, different limb bone epiphyses fuse in a predictable order and rate through life (Lister 1999). During excavations at Kraków Spadzista Street (B), numerous diaphyses of long bones and unfused epiphyses were found. They come from animals that were still growing at the time of death. It is possible to divide the long bones into two age categories: the first one before fusing of epiphyses and a second one after epiphyses have completely fused. It is possible to describe the age of mammoth individuals based on epiphyseal fusion for 43 humeri, 51 femora, and 43 tibiae. Most humeri (n = 35, 81 %) belong to animals below 12 years old and only one humerus (3%) comes from an animal above 43 years in age. Approximately 86% of femora (n = 44) were under 34 years old and 76% of tibiae (n = 33) were under 26 years of age.

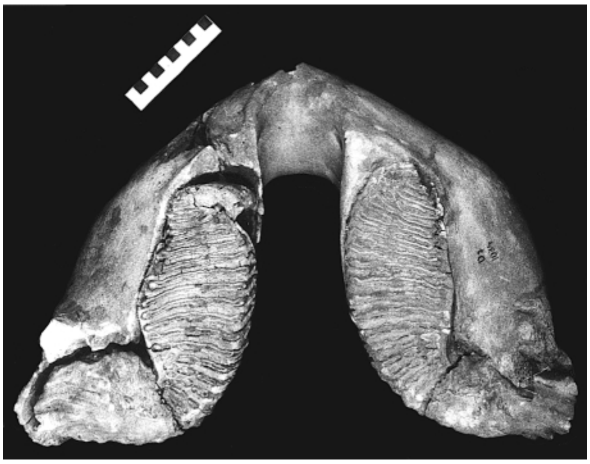

Fig.2 - Mammoth mandible with two abnormally twisted M_3.

Fig.3 - Neural spinosus of mammoth vertebrae with additional hole.

Fig.4 - Mammoth upper cheek tooth with furrows on the cement surface.

Few pathological bones and teeth were found at Kraków Spadzista Street (B). These included two carpals (*hamatum* and *capitatum*) that are fused together and four ribs that were broken and then healed during life. One mandible that belongs an individual around 40 years of age has two abnormally twisted M_3s (the last cheek teeth) (Fig. 2). The proximal ends of these teeth are twisted in the direction of the curve of the tooth.

Seven neural spinosus have additional holes (Fig. 3) and two neural spinosus of thoracic vertebrae are fused.

Especially noteworthy are three mammoth fibulae, which were broken and healed. A low number of abnormalities found on mammoth bones from Spadzista could suggest that this population was in good health. However 111 (about 30%) of lower and upper cheek teeth show visible furrows and small holes on the cement surface, which might be reflect a tooth defect such as hypoplasia (Fig. 4). If these furrows are hypoplasia, they might be an indication of periods of nutritional stress in this mammoth population.

Six percent of the mammoth bones show numerous carnivore gnawing marks, most of which are located on long bone diaphyses and epiphyses; however, other elements show these marks of carnivore activity also. Approximately one percent of identifiable elements show marks that may be the result of trampling, indicating that the bone deposit was visited several times by mammoths before final burial.

Amongst the huge number of mammoth bones, stone artifacts belonging to the Kostenki-Avdeevo (Gravettian) culture were found. Although many shouldered points, backed bladelets, and other tools were ascertained, cut marks on the bones are very rare.

CONCLUSION

Mammoth remains from the Kraków Spadzista Street (B) site come from one population, which lived during the Last Glacial Maximum about 20,000 years ago. Few abnormalities of bones and teeth in addition to the age profile support the argument that the mammoths were probably in good health.

It is possible that this huge mammoth bone assemblage was deposited in the same location where the mammoths died. Soffer (1993) proposed that such deposits - containing large numbers of mammoth bones representing all skeletal elements and age classes, as well as a scarcity of cut marks and a relatively extensive record of scavenger gnaw marks - are non-cultural accumulations.

Tab.2 - Mammoth bones representation at Krakow Spadzista Strret (B).

Bone	NISP	MNE dex	MNE sin	MNI
ATLAS	**92**	-[a]	-[a]	**62**
AXIS	**51**	-[a]	-[a]	**30**
STERNUM	**8**	-[a]	-[a]	**7**
SCAPULA	**103**	23	22	**23**
HUMERUS	**84**	26	24	**26**
ULNA	**106**	28	42	**42**
RADIUS	**119**	40	45	**45**
PISIFORME	**17**	8	9	**9**
LUNATUM	**40**	25	15	**25**
TRAPEZIUM	**21**	12	9	**12**
TRIQUETRUM	**41**	23	18	**23**
SCAPHOIDEUM	**24**	13	9	**13**
TRAPEZOIDEUM	**28**	13	15	**15**
HAMATUM	**38**	21	16	**21**
CAPITATUM	**25**	11	14	**14**
I METACARPALE	**8**	3	5	**5**
II METACARPALE	**30**	13	17	**17**
III METACARPALE	**29**	16	13	**16**
IV METACARPALE	**32**	11	17	**17**
V METACARPALE	**16**	13	3	**13**
PELVIS	**135**	16	26	**26**
FEMUR	**125**	27	31	**31**
TIBIA	**101**	22	27	**27**
FIBULA	**80**	22	33	**33**
CALCANEUS	**37**	17	20	**20**
ASTRAGALUS	**59**	30	29	**30**
NAVICULARE	**52**	23	26	**26**
CUBOIDEUM	**24**	11	13	**13**
CUNEIFORME LATERALE	**32**	19	13	**19**
CUNEIFORME INTERMEDIUM	**23**	12	11	**12**
CUNEIFORME MEDIALE	**13**	7	6	**7**
II METATARSALE	**22**	9	13	**13**
III METATARSALE	**28**	14	14	**14**
IV METATARSALE	**24**	17	7	**17**
V METATARSALE	**10**	6	4	**6**

-[a] MNE was not counted

Such a large skeletal accumulation from 71 mammoths at Kraków Spadzista Street (B) on a relatively small surface suggests a place where a prolonged process of bone accumulation occurred, and not a location where a single event took place. This hypothesis is confirmed by the presence of trampling marks and different weathering stages visible on the mammoth bone surfaces. It is impossible to know if Spadzista reflects human hunting of mammoth herds or of individual animals, or if the bones resulted from natural mortality of mammoths and the carcasses were subsequently utilized by Paleolithic people. It is possible that Kraków Spadzista Street (B) represents a combination of these different events.

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REFERENCES

Haynes, G. 1991. *Mammoths, Mastodonts and Elephants: Biology, Behavior, and the Fossil Record.* Cambridge.

Kozłowski, J.K. & Sachse-Kozłowska, E. 1974. Archeological finds. In Upper paleolithic site with dwellings of mammoth bones - Cracow, Spadzista street B. *Folia Quaternaria*, 44: 23-77.

Kubiak, H. & Zakrzewska, G. 1974. Fossil mammals. In Upper paleolithic site with dwelling of mammoth bones- Cracow Spadzista Street (B). *Folia Quaternaria*, 44: 77-95. Kraków.

Lister, A.M. 1999. Epiphyseal fusion and postcranial age determination in the woolly mammoth Mammuthus primigenius. In G. Haynes, J. Klimowicz and J.W.F. Reumer (eds.), Mammoths and the mammoth fauna: studies of an extinct ecosystem. *Deinsea* 6: 79.

Lipecki, G. & Wojtal, P. 1996. Mammoth population from Cracow Spadzista Street (B) site. *Acta zool. cracov.*, 39 (1): 289-292.

Sobczyk, K. 1995. Osadnictwo wschodniograweckie w dolinie Wisły pod Krakowem. *Rozprawy habilitacyjne* UJ, 303. Kraków. (In Polish).

Soffer, O. 1993. Upper Paleolithic adaptations in central and Eastern Europe and man/mammoth interactions. In Soffer, O. & Praslov N.D. (ed.), *From Kostenki to Clovis, Upper Paleolithic - Paleo-Indian Adaptations.* 31-49.

The Upper Palaeolithic mammoth site at Halich (Ukraine)

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SUMMARY: The Halich site was discovered in 1988 and the first excavation was made in 2000. During this excavation 151 mammoth bones and 105 flint tools were found at the site. The age of this site is about 24 ka to 14 ka and could be connected with the Epigravettian culture. This is probably a mammoth butchering or killing site

The Upper Palaeolithic mammoth site of Halich (NW Ukraine; 49°7’ N, 24°43’ E) was discovered by M. Bandryvski in 1988. In 1997 Sytnik began the study of the site (Sytnik *et al.* 1999). Halich lies on the Halich Hill, a high terrace of the Dniester river right bank. Archaeological and paleontological field studies were started in the year 2000. Three trenches covering 65 square meters were excavated. In the loess layer a very well-developed Upper Palaeolithic culture layer (ca. 10-20 cm thick) was found, with fine remains of hearths, charcoal, and bones. This layer is correlated with the Rovno interphase within the Valdaian/Vistulian loess.

At Halich 151 remains of woolly mammoth - *Mammuthus primigenius* (Blumenbach 1799) were recovered. The bone assemblage includes 38 rib and 19 vertebral fragments as well as six nearly complete cervical vertebrae and two fragments of sacrum. In addition, two fragments of femur, two radii, three unfused tibia epiphyses, and four fragments of innominate were found. In this cultural horizon 14 small bones were recovered, including two carpus bones, one calcaneus, six metapodials, four phalanges and one patella. Although the mammoth bones were discovered in a few clusters, the anatomical order was not visible. (Figs. 1, 2)

At Halich, 18 fragments of teeth were present; unfortunately they were mainly isolated lamellae of cheek teeth. Remains of one mandible with both M2s were discovered. On the basis of tooth wear, the age of this animal was estimated to be 12-14 years old. Similar to other bones in the site, the preservation of the mandible was poor.

Green-bone breakage of some bones suggests that people practised marrow extraction. All bone surfaces show very intensive root etching, making it impossible to carry out more detailed taphonomic study of the mammoth remains.

Four tibiae and two ischium bones belonging to two different individuals were found at the site, indicating a minimum of two mammoths. The unfused tibia epiphyses from Halich indicate that both mammoth individuals were less than 26 years old (Lister 1999). Based on the mandibular toothwear, it appears that at least one mammoth was about 12-14 years old.

Five concentrations of charcoal were encountered in the cultural level. Flint artefacts were found in these concentrations, including one large cluster of 27 flint artefacts in concentration number 1. The flint had been transported to the site as unworked nodules, probably originating in the Dniester valley. Cores were reduced at the site and the flint assemblage suggests that mammoth meat and bones were processed on-site.

Fig.1 - General view of the south-west part of the mammoth bone assemblage.

Fig.2 - General view of ther south-east part of the mammoth bone assemblage.

Unfortunately no characteristic tools or points were found in the Halich site, so it is impossible to distinguish the culture that is represented. However, the geological data indicate that these findings lie in the upper part of younger Vistulian loess, dating to 24 - 14 kyr. The Epigravettian culture developed during the first millennia of this period in the Dniester valley (Djindjian *et al.* 1999).

CONCLUSION

The presence of a large number of mammoth bones (limb bones, ribs and vertebrae, mandible and innominate), small bones such as phalanges or metapodials and unfused tibia epiphyses could suggest that the Halich site is situated at the place where mammoths died. The green-bone breakage, remains of hearths, and large number of flint tools could suggest that it is an Upper Palaeolithic mammoth butchering or kill-butchering site. Excavations will continue at the site next year, and we will seek support for these hypotheses.

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REFERENCES

Djindjian, F., Koslowski, J., Otte, M. 1999. *Le paléolithique supérieur en Europe.* Paris: Armand Colin/HER.

Lister, A.M. 1999. Epiphyseal fusion and postcranial age determination in the woolly mammoth Mammuthus primigenius. In G. Haynes, J. Klimowicz and J.W.F. Reumer (eds.), Mammoths and the mammoth fauna: studies of an extinct ecosystem. *Deinsea* 6: 79-87.

Sytnik, A., Bogucki, A., Łanczont, M., Madeyska, T. 1999. Stanowisko górnopaleolityczne Halicz I [In Polish with English summary], *Materiały i Sprawozdania Rzeszowskiego Òrodka Archeologicznego*, Tom XX: 15-021.

The World of Elephants - International Congress, Rome 2001

Unique preservation of a mammoth carcass

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Remains of a mammoth (*Mammuthus primigenius*) - bones and soft tissues - have been found occasionally in the vicinity of the village Starunia, near Nadwórna, at the foot of the Carpathian Mountains, (now Western Ukraine). The carcass of the mammoth layed beneath a 12.5 m thick layer of silt, containing insertions of earth-wax and imbued with salt and petroleum vapour. In comparison with Rancho la Brea (California), where only bones were preserved, in Starunia one mammoth and four rhinoceroses were found with preserved soft tissues. Among them is the famous world-wide known woolly rhinoceros of Starunia, the only specimen in the world completely preserved, and stored in the Museum of Natural History of the Polish Academy of Sciences in Cracow. The mammoth carcass and those of the woolly rhinoceroses have been conserveted in a natural way due to the earth-wax, salt and petroleum vapour. The ^{14}C dating of the mammoth carcass is 22,600 years BP while the finds of the four woolly rhinoceroses of this site are dated between 36,000 and 14,200 years BP.

Two Mammoth sites in La Alta Mixteca (Oaxaca), México

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Since the beginning of this century, paleontologist were interested by the abundance of fossils of different ages found in Southwestern Mexico. Our area of study is the Teposcolula District in La Alta Mixteca (Oaxaca). This area is a complex system of valley-lakes that extends from the Neovolcanic Plateau into Guatemala, with a rich fossil record of Pleistocene age. One of the lakes lasted from the Pleistocene until the XVI century, as it can be seen in a painting in the Convent of San Pedro and San Pablo, in the town of Teposcolula.

The deformation of sedimentary rocks and of the Precambrian basement gave origin to a structural depression that formed an endorreic basin, in which continental sediments of the Tertiary were deposited. The volcanic activity stopped in the Upper Pleistocene, after having caused a new fisiographic rejuvenation. The igneous rocks dispersed in the area building up a hydrologic barrier that fractioned the vast Mixteca Basin into sub-basins. The Quaternary deposits consist basically in fills of the valley (crushed stone), and in lacustrine deposits.

Two areas of the District of Teposcolula attracted our attention: the towns of San Felipe Ixtapa and of La Trinidad Vista Hermosa. In the first, there is a group of footprints that belong to different Pleistocene-early Holocene animals such as mammoths, camelids, bison, deer, horses and small mammals such as rabbits. On the same rocks human footprintswere detected. There are also petroglyphs that represent some of these animals and some bones disturbed by erosion.

During the survey, we were able to find fossil remains of camelids, deer, bison and horses, but not of mammoth. In the area we also discovered much flint lithic material (both waste products and projectile points).

In the second site, bones were found and collected by fieldworkers during their traditional "*Tequio*". They later invited us to work on their findings. All over, two mammoth bones and two molars were discovered, partially destroyed by the stream that crosses the town. In the last day of our survey , the rain uncovered the proximal end of a mammoth tusk and part of the skull of a young specimen.

The area can provide important information on the micro-environments that determined the seasonal movements of the first human populations, particularly if we analyse the mammoth bones (enamel growth, trace elements, etc.), and correlate them with the micropaleonviromental evidence and resources availability during the Upper Pleistocene. This will hopefully allow the formulation of new hypotheses on the early human peopling of the Americas.

Un donario fittile con elefanti e Cerbero dal santuario di Portonaccio a Veio

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SUMMARY: During Veii's excavations in 1945-46, M. Santangelo found, in the area of Portonaccio's shrine, a little *donarium* located in a cistern. On it, we can reconstruct elephants in association with Cerbero's figure, with a probable connection with chthonian cults. It is also possible, however, to suppose that this object, whose subject is so unusual, would refer to an historical event: in fact we know that, during the battle of Benevento against Pirro and his elephants, a little elephant was wounded, and, moreover, four captured elephants were parading in Rome in 275 BC. So, we could imagine that a soldier serving in M. Curio Dentato army, maybe from Veii, would have offered this peculiar object (an *unicum* with no comparisons) as a souvenir of that war, when Roman people saw elephants for the first time.

Due piccoli elefanti fittili (Fig. 1) furono rinvenuti nel riempimento della cisterna circolare in opera quadrata di blocchi di tufo, scavata dalla Santangelo (1948, 1949, 1952) in modo discontinuo tra il 1945 ed il 1946, nel santuario di Portonaccio a Veio; recentemente individuata, è stata posizionata nella zona antistante il tempio, fra questo e l'altare (Colonna 1998).

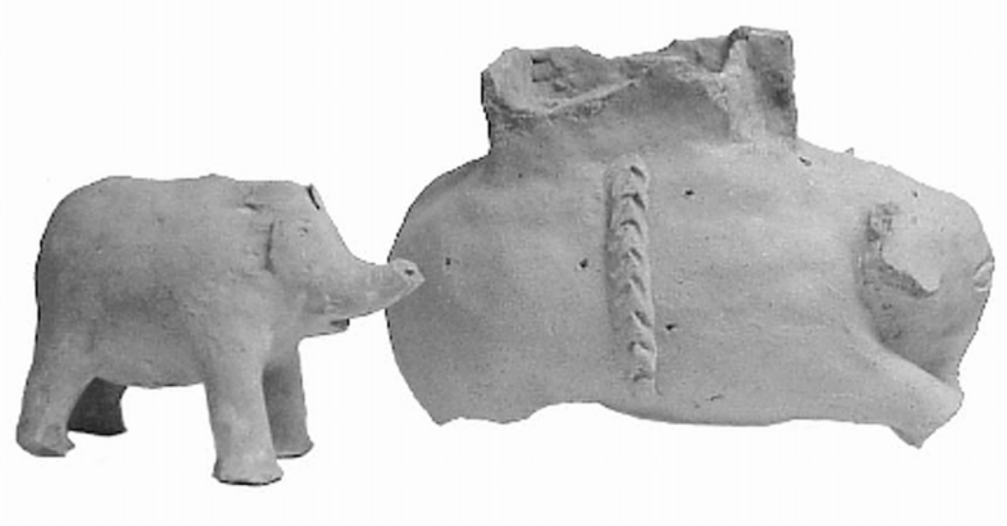

Fig.1 - Roma, Museo Nazionale Etrusco di Villa Giulia, i due elefanti fittili. Foto autore.

Fig.2 - Roma, Museo Nazionale Etrusco di Villa Giulia, piatto da Capena. Foto autore.

Lo studio sistematico del contesto di rinvenimento ha consentito di ricomporre, con gli elefanti e con altri elementi, un piccolo donario fittile di carattere eccezionale, che non trova paralleli, fino ad ora, in ambito etrusco ed italico, oggetto di uno studio specifico al quale si rinvia per tutti gli approfondimenti (Ambrosini 2001, al quale si rinvia per tutti i riferimenti bibliografici). Particolarmente delicata, stante la lacunosità del manufatto, è la questione riguardante l'interpretazione del donario che, realizzato appositamente per essere offerto nel santuario, solleva una serie di interessanti interrogativi. Le ipotesi di lavoro, certamente suscettibili di modifica sulla base di nuovi elementi, allo stato attuale, sembrano esplicarsi su diversi livelli. La Santangelo (1948) ricollega i due elefanti alla nota raffigurazione presente sul piatto da Capena (Fig. 2) e riferisce la loro associazione al fatto che l'uccisione degli elefantini in battaglia rendeva particolarmente feroci le madri, che seminavano maggiore strage tra i nemici.

Per l'elefante con la torretta, motivo tardo ellenistico, identifica il prototipo nelle due ben note *phalerae* d'argento dell'Ermitage; gli elefanti, considerati di specie asiatica per le ridotte dimensioni delle orecchie e delle zanne, potrebbero essere un riferimento agli elefanti da guerra di Pirro. Secondo lo Scullard (1974) è impossibile stabilire se i nostri esemplari, che datano al III o II sec. a.C., siano animali di specie asiatica o africana; tuttavia sembra incline a considerarli di specie africana ed a collegarli ad Annibale. In seguito, sono stati interpretati dal Colonna (1985) come “dono votivo a Minerva, quale dea della *virtus* militare” (collegato alle guerre di Pirro), che potrebbe aver commemorato, come i *pocola* di Capena, Aleria e Norchia, dipinti con lo stesso soggetto, la vittoria dei Romani a Benevento nel 275 a.C. Gli elementi maggiormente indiziati per il riconoscimento della specie (asiatica o africana) - cioè le orecchie - sono lacunosi, pertanto non sembra sia possibile collegare con certezza i due elefanti alle imprese di Pirro o di Annibale. Tra i materiali del riempimento della cisterna è stato possibile rintracciare un altro animale - un cane - che la presenza di tre teste permette di identificare con sicurezza con Cerbero (Fig. 3).

Già fatto fotografare dalla Santangelo con gli elefanti, appartiene con ogni probabilità allo

Fig.3 - Roma, Museo Nazionale Etrusco di Villa Giulia, Cerbero. Foto autore.

Fig.4 - Roma, Museo Nazionale Etrusco di Villa Giulia, base anulare di sostegno, veduta della sezione. Foto autore.

stesso gruppo: esso infatti possiede le medesime caratteristiche tecniche e stilistiche dell'elefantino. È stato possibile rintracciare anche la piccola testa laterale destra del Cerbero, rinvenuta da E. Stefani il 25 luglio 1919, a Portonaccio nella zona dell'altare, dove forse il donario era collocato in origine. Si è poi ricostruito un oggetto di forma circolare, interpretabile come base di sostegno (Fig. 4), in argilla rosa scialbata, identica a quella dell'elefantino e del Cerbero. A forma di anello cilindrico, cavo (simile ai *kernoi*), con orlo interno scanalato, presenta internamente un incavo semicircolare (per l'innesto di un disco o perno centrale o per accogliere, ad es., offerte alimentari o altro). Sulla superficie superiore vi sono vari gruppi di fori: un gruppo di quattro coincide perfettamente con le zampe dell'elefantino; vicino, due impronte, potrebbero essere destinate all'ancoraggio delle zampe anteriori del Cerbero. L'associazione tra la base, l'elefantino e Cerbero, sembra essere supportata da elementi di carattere tecnico e stilistico. Maggiori difficoltà pone l'elefante con torretta, d'argilla beige maggiormente ricca di inclusi: la pesantezza e le maggiori dimensioni dell'oggetto non consentono un posizionamento al di sopra della fascia anulare della base e lascerebbero presupporre l'ancoraggio su un'altra base, collocata presumibilmente vicino a quella anulare (Fig. 5).

Un suo eventuale posizionamento in relazione alla nostra base potrebbe essere tuttavia postulato sia in considerazione del tema affron-

Fig.5 - Ipotesi di ricostruzione del donario, con due basi. Foto autore.

tato, sia per l'assenza, nel santuario, a quanto risulta, di altri animali votivi e di altre basi di sostegno analoghi. In un ulteriore tentativo di ricostruzione è possibile forse collocare l'elefante con torretta al centro della base - su un pilastro circolare soprelevato, che va ad innestarsi nell'incavo presente in essa - circondato da animali (almeno quattro), due dei quali costituiti dal Cerbero e dall'elefantino (Fig. 6).

La cronologia del manufatto, nel quadro delle produzioni d'età ellenistica, potrebbe essere circoscritta tra la fine del IV e la prima metà del III sec. a.C., quando si assiste ad una consistente frequentazione del santuario, testi-

Fig.6 - Ipotesi di ricostruzione del donario, con una sola base. Foto autore.

moniata da un elevatissimo numero di ceramiche rinvenute nella medesima cisterna. L'interesse precipuo del donario consiste nella presenza di elefanti, le cui raffigurazioni cominciano ad essere attestate in ambito italico dall'età ellenistica, e comunque non particolarmente frequenti, e nell'associazione con Cerbero, mai attestata in alcun episodio mitico. Gli elefanti fittili finora noti, dall'Asia Minore e dall'Egitto, appartengono alla classe degli oggetti votivi commemoranti le vittorie sui Galati di Antioco I o di Eumene II oppure raffiguranti il ritorno dall'India di Dioniso ed Arianna (Mollard Besques 1963; Bienkowski 1928), o delle lucerne plastiche. Un elefantino fittile è stato rinvenuto ad Arpi nella tomba XIII della necropoli dei Monterozzi (Steingräber 2000). Elefanti accompagnano il defunto nel suo ultimo viaggio (es. raffigurazioni sul carro funebre di Alessandro Magno e sulla tomba di Pirro ad Argo). In ambito etrusco ed italico elefanti sono presenti su ceramica dello stile di *Gnathia* (Walker 1991), sui già citati *pocola deorum*, su ceramica calena (Bienkowski 1928), nella scultura in bronzo, pietra e terracotta (Reinach 1892; Settis 1966; Scullard 1974; Coarelli 1994), in pitture tombali (Baglione 1976; Steingräber 1985), su *aes signatum* e monete (Nenci 1955; Scullard 1974; Baglione 1976). La raffigurazione di Cerbero in ambito etrusco compare su ceramica a figure nere, a figure rosse, su specchi, ciste e scarabei incisi, su monete, su sarcofagi litici ed urnette fittili (Woodford & Spier 1992) ed in pitture tombali (Cristofani 1967; Buranelli 1987; Blanck & Proietti 1986). Nell'antichità divenne comune l'idea che l'elefante avesse timore di piccoli animali. Il donario potrebbe raffigurare la trasposizione mitica di una lotta tra un cane ed un pachiderma (cfr. ad es., quella del cane di Alessandro Magno; Plinio, *N.H.*, VIII, 61). Nella battaglia di Benevento il ferimento di un elefantino fece eccitare la madre ed imbizzarrire gli altri elefanti; i Romani vinsero, catturarono otto elefanti, quattro dei quali furono fatti sfilare a Roma, nel trionfo di Manio Curio Dentato del 275 a.C. (avvenimento commemorato forse nei *pocola*; Peruzzi 1990). Non è escluso che il donario, un *unicum*, così complesso dal punto di vista strutturale e dunque legato ad una volontà precisa, possa racchiudere il riferimento a tale avvenimento storico. Il dedicante potrebbe essere identificato con un soldato dell'esercito di Manio Curio Dentato, forse residente a Veio, zona ben popolata in età medio-repubblicana. Poiché l'elefante è un animale esotico, mai visto a Roma e dintorni prima del 275 a.C., difficilmente poteva essere preso a paradigma dell'affetto materno da parte del dedicante e decodificato nel santuario da parte dei fedeli; inoltre l'elefante con torretta sembra collegato sempre ad un uso militare (Armandi 1843; Reinach 1892), o tutt'al più venatorio. E' possibile che il donario raffiguri, attraverso animali assunti a simbolo, aspetti sacrali connessi al culto svoltosi nel santuario (elefante simbolo della luce e della vita connesso con Apollo, contrapposto a Cerbero, simbolo dell'oltretomba e quindi del buio e della morte; Matz 1952; Strazzulla 1990; Morel 1995). Gli spunti di riflessione offerti dall'associazione elefante/Cerbero sono molteplici: natura insolita/mostruosità, provenienza da terre lontane/Ade, longevità/morte, o scorta all'Ade/Ade. L'interpretazione, legata ad un significato allegorico più ampio, di carattere religioso ed escatologico, resta tuttavia possibile: essa, comunque, dovrebbe implicare un'adozione precoce di una simbologia assai sofisticata di matrice orientale e filtrata attraverso la cultura ellenistica.

BIBLIOGRAFIA

Ambrosini, L. in stampa. Cerbero e l'elefante. Ipotesi sulla ricostruzione di un donario fittile dal santuario di Portonaccio a Veio. In M. Torelli & A. Comella (eds.), *Depositi votivi e culti dell'italia antica dall'età arcaica a quella tardo-repubblicana*. Atti Convegno Perugia 2000.

Armandi, P. 1843. *Histoire militaire des éléphants jusqu'à l'invention des armes à feu*. Paris.

Baglione, M.P. 1976. Su alcune serie parallele di bronzo coniato. In *Contributi introduttivi allo studio della monetazione etrusca*. Atti Convegno Napoli 1975: 153-180. Roma.

Bienkowski, P. 1928. *Les Celtes dans les artes mineurs gréco-romains avec des recherches iconographiques sur quelques autres peuples barbares*. Cracovie.

Blanck, H. & Proietti, G. 1986. *La tomba dei Rilievi di Cerveteri*. Roma.

Buranelli, F. 1987 (ed.). *La Tomba François di Vulci*. Catalogo Mostra Città del Vaticano 1987. Roma.

Coarelli, F. 1994. Due fregi da *Fregellae*: un documento storico della prima guerra siriaca? *Ostraka III*, 1: 93-108.

Colonna, G. 1985 (ed.). *Santuari d'Etruria*. Catalogo Mostra Arezzo 1985. Milano.

Colonna, G. 1998. Veio: i santuari di Portonaccio e Piano di Comunità. In L. Drago Troccoli (ed.), *Scavi e ricerche archeologiche dell'Università di Roma "La Sapienza"*: 139-143. Roma.

Cougny, E. 1887. S.v. *canis*. In C. Daremberg & E. Saglio, *Dictionnaire des antiquités grecques et romaines*, I, 2: 877-890 Paris.

Cristofani, M. 1967. Ricerche sulle pitture della tomba François di Vulci. I fregi decorativi. *DArch* I, 2: 186-219.

Matz, F. 1952. Der Gott auf dem Elephantenwagen. *Verlag der Akademie der Wissenschaften und Literatur in Mainz*: 718-763. Mainz.

Mollard Besques, S. 1963. *Catalogue raisonné des figurines et reliefs en terre-cuite grecs et romains II. Myrina.* Paris.

Morel, J.P. 1995. Des éléphants au Palatin (à propos d'une antéfixe de la Vigna Barberini). In "*Alla signorina*". *Mélanges offerts à Noëlle de la Blancharière*: 303-309. Rome.

Nenci, G. 1955. Un prodigio dei *signa* nella battaglia di *Ausculum* e le origini di un *topos* fisiologico. *RFIC* LXXXIII, N.S. XXXIII: 391-404.

Peruzzi, E. 1990. Gli elefanti di Curio Dentato. In E. Peruzzi, *I Romani di Pesaro e i Sabini di Roma*: 281-316. Firenze.

Reinach, S. 1892. S.v. *elephas*. In C. Daremberg & E. Saglio, *Dictionnaire des antiquités grecques et romaines*, II: 536-544. Paris.

Santangelo, M. 1948. Per la storia di Veio fra la conquista romana ed il *Municipium Augustum Vejens*. Iscrizioni in latino arcaico su *pocula deorum*. *RAL* Ser. VIII, III: 454-464.

Santangelo, M. 1949. Iscrizioni in latino arcaico su due *pocula deorum* provenienti da Veio. *Latomus* VIII: 37-45.

Santangelo, M. 1952. Veio, santuario "di Apollo". Scavi fra il 1944 e il 1949. *BA* XXXVII: 147-172.

Scullard, H. H. 1974. *The Elephant in the Greek and Roman World*. London.

Settis, S. 1966. Contributo a Bomarzo. *BA* LI 1-2: 17-26.

Steingräber, S. 1985 (ed.). *Catalogo ragionato della pittura etrusca*, Milano.

Steingräber, S. 2000. *Arpi – Apulien – Makedonien. Studien zum unteritalischen Grabwesen in hellenistischer Zeit.* Mainz.

Strazzulla, M.J. 1990. *Il principato di Apollo. Mito e propaganda nelle lastre "Campana" dal tempio di Apollo Palatino.* Roma.

Walker, S. 1991. *Roman Art. British Museum.* London.

Woodford, S. & Spier, J. 1992. S.v. *Kerberos.* In *Lexikon Iconographicum Mythologiae Classicae* VI,1: 24-32. Zürich und München.

Un frammento marmoreo con testa di elefante dall'area archeologica centrale di Roma

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SUMMARY: A fragment of marble sarcophagus with the head of an elephant was found during recent (2000) excavations in a cellar of the former cloister of Sant'Ambrogio della Massima (Rome). This building is located in the southern zone of the ancient *Campus Martius* and includes parts of the Porticus of Octavia and of the Porticus of Philippus, two contiguous monuments which formed a single unit. The archaeological excavations gave elements about the architectonic structure of the two Porticus, both in roman and in middle age.The fragment with an elephant head could be part of a sarcophagus with the rapresentation of Dyonisus triumph on Indians, a well known pattern from the second century AC. This piece, however, could also be part of a non dyonisiac relief.

1. Lo scavo e la topografia del sito in età romana

Nei mesi giugno - novembre 2000 sono state eseguite indagini archeologiche a Roma, all'interno di alcuni ambienti sotterranei dell'ex-convento di Sant'Ambrogio della Massima, ove è stato rinvenuto un frammento marmoreo con testa di elefante, che si presenta in questa occasione. L'intervento, in questa prima fase, ha interessato solo alcuni vani del complesso, perché ha dovuto adeguarsi alle priorità del cantiere di restauro del palazzo rinascimentale

L'area oggetto di scavo si trova nella zona meridionale del Campo Marzio, noto in questo settore dalle notizie fornite dalle fonti scritte e figurate, soprattutto la Pianta Marmorea di Roma antica di età Severiana (Carretton *et al.* 91-92, tav. 29) e dai ritrovamenti archeologici. In particolare la zona indagata insiste in parte all'interno del Portico d'Ottavia, in parte all'interno del Portico di Filippo, due strutture contigue autonome, ma che costituivano un complesso in qualche modo unitario (Viscogliosi 1993-2000).

Il Portico d'Ottavia, costruito, al posto del più antico Portico di Metello, da Augusto a nome della sorella Ottavia, era un quadriportico di considerevoli dimensioni, con la fronte sul Circo Flaminio, che cingeva i due templi di Giove Statore e di Giunone Regina. Il Portico di Filippo, più piccolo, fu eretto probabilmente dal patrigno di Augusto intorno al tempio di Ercole Musagete. Ambedue le strutture hanno avuto varie fasi di restauro e rifacimento.

Data l'importanza della zona monumentale, gli scavi archeologici sono stati finalizzati all'acquisizione di dati sull'impianto architettonico dei due edifici, in particolare sono stati messi in luce due tratti di muratura in blocchi di tufo lionato probabilmente pertinenti alla fase augustea del Portico di Filippo. Notevolmente importanti i dati acquisiti sull'occupazione tardoantica e medievale, finora poco nota. È venuto in luce un pavimento in lastre di marmi colorati di recupero e diversi muri tardoantichi in opera vittata, disposti in modo da disegnare una serie di ambienti contigui. Numerosissime le trasformazioni ed i rifacimenti successivi che si sono protratti fino a tempi recenti.

2. Il frammento con testa di elefante

Probabilmente a qualcuno degli interventi edilizi di epoca post-antica si deve ascrivere la presenza del frammento con testa di elefante a rilievo piuttosto alto (m. 0,22 x 0,14 x 0,8), che è stato rinvenuto spezzato in due parti in un accumulo di detriti depositati sul pavimento di una delle cantine. Il pezzo, in marmo bianco a grana grossa, presentava nuclei di malta all'interno della frattura, che pertanto deve essere ritenuta antica (Fig. 1).

Nel rilievo è rappresentata la testa di un elefante in movimento verso destra; sono visibili l'occhio, evidenziato da un solco profondo, parte della proboscide e di una zanna. L'orecchio destro è conservato solo parzialmente. La rugosità della pelle è resa con una serie di linee incise parallele, intersecatisi secondo un motivo a rete; tale motivo convenzionale è indicato da Plinio (*NH*, VIII 10, 30) come *cancellata cutis* (Sichtermann 1979: 352 ss.).

Il frammento è certamente pertinente ad un sarcofago, che potrebbe appartenere al numeroso gruppo con rilievi a soggetto dionisiaco, in particolare a quelli con trionfo di Dioniso sugli Indiani (sull'iconografia di Dioniso Gasparri 1986, 1: 413-414, 540-566; 2: 296-406, 428-455, figure). I sarcofagi con soggetto dionisiaco cominciano a diffondersi in età adrianea; a partire dall'età antonina la produzione si intensifica. A quest'epoca va ricondotta l'apparizione di rappresentazioni connesse con il trionfo indiano di Bacco (epiclesi romana di Dioniso). Il mito che narra della guerra e del trionfo sugli Indiani di Dioniso (*Anth. Pal.* 9, 524, 10; Nonn., *Dion.* 13-40, *passim*) nasce in ambiente ellenistico per effetto delle esaltanti conquiste orientali di Alessandro Magno e di Tolomeo Filadelfo (Matz 1968: 267-279, nn.130-141, tavv.158-163; Gasparri 1986, 1: 558, nn.241-247; 2: 452-453, figure). Tale tema narrativo diviene attuale all'epoca dei trionfi del giovane Lucio Vero in oriente; in queste scene l'elefante è rappresentato mentre traina il carro del dio o mentre trasporta prigionieri o spoglie del trionfo. La rappresentazione del trionfo di Dioniso sul carro trainato da centauri, pantere o elefanti fonde temi della pittura dinastica di ambiente ellenistico alle scene di trionfo che appaiono nei rilievi storici contemporanei (Gasparri 1986, 1: 564-565).

Il nostro frammento non consente tuttavia, per le sue ridotte dimensioni, di stabilire con certezza la sua pertinenza a tale contesto figurato.

Nel presentare un frammento analogo conservato al Museo Nazionale Romano, Luisa Musso mette in evidenza (Musso 1993: 15-17) la possibilità che la figura dell'elefante compaia su sarcofagi in scene narrative diverse dal trionfo di Dioniso sugli Indiani, ad esempio in una scena di caccia al cinghiale su una *lenòs* di Ostia, (Andreae 1980: 154, n.61). La studiosa

Fig.1 - Frammento marmoreo con testa di elefante (S. Ambrogio - Roma).

ricorda, inoltre, come la figura dell’elefante possa essere utilizzata in un contesto simbolico, piuttosto che narrativo. Su una lastra di Ostia, ad esempio, sono rappresentate due coppie di elefanti affrontate araldicamente; gli animali sorreggono con le proboscidi i tondi contenenti i busti dei defunti (Sichtermann 1979: 355, nota 37 con bibliografia precedente). In questo contesto all’elefante è stata attribuita una valenza simbolica, connessa al simbolismo cosmico e all’idea di eternità, derivante dalla ben nota longevità dell’animale. Da non sottovalutare la possibilità di una trasposizione in ambito funerario del motivo trionfale connesso all’elefante, che ha, come si è detto, la sua origine in ambito ellenistico e venne ripreso a Roma già nella tarda età repubblicana: Plutarco (*Pomp.*, 14, 6) descrive il trionfo di Pompeo su una quadriga trainata da elefanti.

In tutta l’area del Campo Marzio meridionale (propileo del Portico d’Ottavia, area limitrofa al tempio di Bellona, area del teatro di Marcello-Monte Savello, area del Foro Olitorio), durante gli scavi recenti ed ancora in corso di esecuzione, sono venuti in luce con una certa frequenza frammenti di sarcofagi (e più raramente di urne sepolcrali) sia pagani, sia cristiani, di diversa fattura ed importanza, sempre utilizzati come materiale da costruzione, presenti nelle murature superstiti del vecchio quartiere demolito tra la fine dell'ottocento e la prima metà del novecento. Nel caso del frammento con testa di elefante allo stato attuale delle nostre conoscenze è molto probabile che svolgesse un’analoga funzione e che non esistesse alcun legame con l’area in cui è stato rinvenuto.

3. BIBLIOGRAFIA

Andreae, B. 1980. Die Römischen Jagdsarkophage, In *Die Antiken Sarkophagreliefs*. I, II. Berlin.

Carrettoni, G., Colini, A.M., Cozza, L., Gatti, G. 1960. *Pianta Marmorea*. Roma.

Gasparri, C. 1986. *Dionysos e Dionysos Bacchus*. In *Lexicon Iconographicum Mytologiae Classicae* III, Zurigo-Monaco.

Matz, F. 1968. *Die Dionysischen Sarkophage*, II. Berlin.

Musso, L. 1993. In *Museo Nazionale Romano* I, 10*, *Magazzini, I Sarcofagi*: 15-17. Roma.

Sichtermann, H. 1979. Göttlicher Enthusiasmus. *Mitteilungen des Deutschen Archaeologischen Instituts. Roemische Abteilung* 86: 351-374.

Viscogliosi, A. 1993-2000. *Circus Flaminius; Hercules Musarum, aedes; Iuno Regina, aedes in Campo, ad Circum Flaminium; Iuppiter Stator, aedes ad Circum; Porticus Metelli; Porticus Octaviae; Porticus Philippi.* In Steinby (ed.), *Lexicon Topographicum Urbis Romae*. Roma.

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Gli elefanti si radunano presso il fiume Amilo

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SUMMARY: In 79 BC Pompeus Magnus triumphed on a car drawn by four elephants. This choreography inspired a Pompeian fresco in wich the triumpher was *Venus Victrix*, a goddes worshipped by Silla and Pompeus. The reason that prompted, against tradition, to use elephants drawing the image of the god – or the deified triumpher – is to be found in the context of the new popularity gained by these animals in I century Rome. Elephants employed in arena shows aroused astonishing emotions of admiration and pity that gave origin to legends about the supposed moral sense of the beast. Among the others, a legend originated in Africa is specially interesting, because it reveals the religious behavior of elephants. The story tells that in the new moon nights pachyderms get togheter to worship the moon, purifying themself with ritual ablutions in the water of rivers.

1. L'ELEFANTE E L'IMMAGINARIO

Fra tutte le immagini, quelle degli animali sembrano essere le più comuni nel repertorio del fantastico. L'orientamento teriomorfo dell'immaginazione è saldamente depositato negli strati profondi dell'esperienza, laddove un duplice livello connota il rapporto dell'uomo con l'animale: uno del tutto obbiettivo, per cui l'oggetto è visto e valutato nella sua realtà, ed un altro simbolico che lo pone su un piano, più o meno condiviso, di connotazione archetipica e plurima che investe l'animale di caratteri spesso molto distanti dalla sua vera natura, come se l'interesse per quest'ultima seguisse addirittura in secondo ordine la polivalenza di significati allegorici, simbolici e metaforici (Durand 1984).

Lungo un itinerario antropologico-culturale le immagini collettive si fissano nella memoria di un popolo o di una comunità per trasmigrare, poi, verso altri gruppi umani. Anche le immagini, spostandosi in questo processo di migrazione, subiscono inevitabili modifiche, adattandosi alla nuova cultura, senza perdere tuttavia l'universalità dei messaggi che veicolano.

Partendo da questo assunto, si cercherà qui di tratteggiare sinteticamente, attraverso due possibili tracce, come la "fortuna" dell'immagine dell'elefante nella cultura occidentale trovi una tappa fondamentale nelle particolari condizioni politiche, sociali e culturali della Roma del III-I secolo a.C.

2. L'INGRESSO DEGLI ELEFANTI A ROMA

I Romani, secondo quanto riferisce Marziale (*Epigram.* I, 17), videro gli elefanti per la prima volta nel 282-273 a.C. durante la guerra contro Pirro. Nel 246 a.C., all'inizio della Prima Guerra Punica furono catturati presso Agrigento cinquanta elefanti, inviati a Roma per incrementare il numero delle bestie che venivano sacrificate negli spettacoli circensi. Centoquarantadue elefanti furono prelevati dal console Lucio Metello nel 241 a.C., alla fine del primo conflitto contro i Cartaginesi, per inviarli a Roma su zattere costruite con file di botti unite fra loro (Livio, *Periocae*, XIX; Seneca, *De brevitate vitae*, XIII, 8). Tali arrivi incrementarono la passione dei Romani per i pachidermi, allevati ed addestrati per allietare la folla nelle arene con danze e pantomime grottesche o per stupirla in parate militari e cortei trionfali. La propensione dei consoli e degli imperatori verso gli elefanti si rileva dai tanti aneddoti e dai resoconti degli storici dell'epoca repubblicana e di quella imperiale, dai quali si evidenzia però un atteggiamento ambivalente nei confronti delle maestose bestie, privilegiate, addirittura adorate ma al contempo vessate e fatte oggetto di ludibrio. Ritenute intelligenti e sensibili, furiose nelle battaglie, possenti nelle arene, su di esse si scaricarono le valenze aggressive e sanguinarie dei loro padroni. Possedere animali feroci fu di moda a Roma: serpenti, tigri e pantere dimorarono presso alcuni imperatori; Augusto e Tiberio furono collezionisti di ossa di pachidermi, conservate presso le loro ville (Svetonio 1974).

Nell'80 a.C. il dittatore Silla fondò una colonia di veterani romani a Pompei, la chiamò *Cornelia Veneria Pompeii*, dedicandola a Venere, ed altre ne fondò in Africa dopo le vittorie lì conseguite. Veneria Rusicade fu una di queste e, come la prima votata a Venere, venne modellata sulle città campane con le quali intrattenne rapporti commerciali e affettivi. Un anno dopo la fondazione di *Cornelia Veneria Pompeii*, il 12 marzo del 79, Pompeo, amico di Silla, trionfò su di un carro tirato da quattro elefanti, la cui coreografia ispirò probabilmente l'iconografia di un dipinto rinvenuto a Pompei, nel quale "la dea [Venere] sta su un cocchio tirato da quattro elefanti: a destra l'accompagna la *Fortuna*, con i piedi poggianti sul globo; a sinistra, una divinità reggente la patera e la cornucopia, che nell'illustrazione ufficiale è identificata con l'*Abundantia*. In quest'ultima è invece ovvio […] riconoscere la *Felicitas*, la dea collegata con Silla e, nell'età di Silla e di Pompeo, onorata accanto a *Venere Victrix* […]. Alla scena principale sottostà, in una stretta fascia, un minore dipinto, in cui persone e scritture accennano alla tintura e al commercio di panni" (Pais 1918: 227-8). Si tratta del negozio di un *vestiarius*, in quanto, come riferiscono Plutarco (*Pseud.*, 145) e Plinio (1982), "sul finire della Repubblica e al principio dell'Impero, i molluschi e le tintorie delle coste africane, particolarmente nella Mauritania (le cosiddette coste Getuliche) goderono di una reputazione del tutto speciale" (Pais 1918: 231). I rapporti fra le colonie numidiche e quelle campane furono caratterizzati da scambi materiali e culturali, per cui è verosimile pensare che "i coloni della Numidia abbiano inviato nell'antica metropoli (*Pompeii*) i segni della loro devozione" (Pais 1918: 231).

Sembrerebbe, dunque, che la nuova coreografia del trionfo romano fosse di origine africana, sebbene, stando a Plinio, fu il dio Libero, o Bacco, il primo a trionfare su di un carro tirato da quattro elefanti dopo aver domato l'India. L'ipotesi dell'origine asiatica di questa coreografia potrebbe per altro esser confortata, ad esempio, dalle antiche raffigurazioni del *pantheon* birmano dei Nat, dove le divinità appaiono sostenute da elefanti. Una di queste raffigurazioni, quella in cui il dio cosmico Thagya-Nat è rappresentato in piedi su di un carro sostenuto da quattro elefanti, richiama da vicino l'iconografia della "Venere Pompeiana" e la coreografia del nuovo trionfo romano.

Alcuni eventi della storia romana, sul finire del I sec. a.C., sono collegati con l'arrivo a Roma di molti pachidermi. Il 12 agosto del 55, per festeggiare il suo secondo consolato, Pompeo dedicò un tempio a *Venus Victrix* e per l'occasione fece combattere venti elefanti contro un gruppo di Getuli della Mauritania (Plinio 1982: 155). Lo spettacolo fu tanto doloroso da sollevare lo sdegno della folla contro il console. Insieme agli elefanti africani giunsero a Roma anche le leggende che gli accompagnatori (i *mahut*) raccontavano su questi animali. Tali leggende passarono dapprima "nelle lettere di Cicerone, nelle memorie del tempo, per poi finire nelle storie e negli annali, perpetuate insieme al ricordo dei giochi di Pompeo" (Passerini 1933: 4).

3. L'ADORAZIONE DEGLI ELEFANTI PER LA LUNA

La leggenda della *adorazione degli elefanti per la luna* è giunta a noi attraverso diverse fonti (Plinio, *Nat. Hist.* VIII, 1-13; Eliano, *de nat. anim.* IV, 10; Dione, XXXIX, 38 5), poiché molti furono gli storici che ad essa si interessarono. Racconta Plinio che "sui monti selvosi della Mauritania, quando comincia a brillare la luna nuova, branchi di questi animali [gli elefanti] scendono ad un fiume chiamato Amilo; lì si purificano solennemente, si spruzzano d'acqua e, dopo avere in questo modo reso onore all’astro, tornano nei boschi, spingendosi davanti i loro piccoli stanchi” (Plinio 1982: 143). Secondo il Passerini (1933) la versione originale di questa leggenda è da ricercare, piuttosto che in Plinio, in Cassio Dione (2000). Questi avrebbe utilizzato come propria fonte non solo Plinio (1982) ed Eliano (1998), ma anche i racconti africani da cui questi autori attinsero la leggenda. Ora, ad avviso del Passerini, questi racconti non contenevano originariamente l’elemento che costituisce, invece, l’interesse principale di Plinio, il fatto che gli elefanti possiedano uno spiccato senso della religiosità, ma solo che essi mostrano di sapere con esattezza quando si verificherà il novilunio. Ed è proprio il fatto che essi abbiano anche una conoscenza del calendario astrale, che desta la meraviglia di Dione: “[gli elefanti] comprendono anche i fenomeni celesti, tanto che al novilunio, prima che la luce della luna si mostri agli uomini, si recano presso fonti di acqua corrente e lì si purificano” (Dione 2000: 53).

L’elemento della venerazione per la luna, che occorre nella versione pliniana, sarebbe perciò mutuato dai resoconti del re di Mauritania Giuba, forse interessato a creare un parallelo della leggenda — che anche Eliano riporta (1998: 473) — secondo cui i pachidermi mostrano di adorare il sole (Giuba, *FgrHist* 275 F 53). Sempre secondo il Passerini, la svista di Giuba potrebbe essere stata facilitata dal doppio significato del termine greco νουμηνία (novilunio), riferibile sia al giorno in cui la luna non è effettivamente visibile, sia al giorno successivo, in cui appare una prima porzione dell’astro.

In polemica con Passerini, Momigliano (1933) afferma che la *salutatio sideris* di cui parla Plinio individua il motivo essenziale e imprescindibile della leggenda, dal momento che non sarebbe plausibile parlare di una cerimonia nel novilunio, sia pure astrologico, che non si riferisca alla luna e alle sue forze. L’omissione di Dione si spiegherebbe dunque semplicemente col fatto che le sue fonti davano evidentemente per implicito il particolare del saluto alla luna. Momigliano cerca una soluzione più semplice del problema. A suo avviso la “cerimonia” descritta da Dione è identica a quella descritta da Plinio, in quanto anch’egli fa esplicito riferimento ad una “purificazione” (καθαρμός). Il resoconto di Dione non si distinguerebbe dunque da quelli di Plinio ed Eliano per il fatto che egli fa risalire la leggenda ad una tradizione più antica; al contrario, attinge come quelli a fonti che intendono caratterizzare l’elefante per le sue virtù quasi umane (non solo la mansuetudine, il coraggio, la temperanza e la saggezza, ma anche il senso di giustizia e di pietà).

Ma forse è possibile dire qualcosa di più in proposito. Eliano non può non dare per scontata la religiosità di animali che, come gli elefanti, “mossi da un impulso naturale, misterioso e intelligente, colgono dei rami freschi nella foresta dove vivono e poi, tenendoli sollevati e volgendo lo sguardo verso la dea [la luna, ovvero Selene], li agitano dolcemente e glieli offrono con gesto supplichevole, come per invocare sopra di sé il favore e la benevolenza” (1998: 223). È ovvio che se l’oggetto di tante attenzioni è proprio la luna, passa in secondo piano l’aspetto sorprendente di una conoscenza dettagliata dei fenomeni celesti. Tutta l’“intelligenza” del misterioso impulso viene così a concentrarsi sulla capacità di riconoscere alla luna attributi divini, e non sulla previsione della sua imminente apparizione. Pur volendo evidenziare l’eccezionalità di questo impulso naturale, Eliano non ha però motivo di specificare il senso preciso del temine “novilunio”, e parla genericamente di un apparire della luna nuova: Πυνθάνομαι σελήνης ὐποφαινομένης νέας, “So che all’apparire della luna nuova …” (l’edizione citata traduce erroneamente “luna piena” anziché “luna nuova”). Ora, non solo Dione non ha nulla da obbiettare alla credenza che gli elefanti partecipino di un certo senso religioso - come dimostra il fatto che egli parla della loro purificazione nello stesso senso di Plinio - ma sembra tradire un interesse positivo per questo aspetto. Forse la sua precisazione sul termine “novilunio” intende suggerire che il comportamento degli elefanti non solo non è determinato da un caso, ma nemmeno da una connessione tra la presenza *visibile* dell’astro e la loro abluzione. Secondo tale ipotesi, la religiosità dell'elefante non sarebbe più un elemento sottinteso del racconto; al contrario, la *salutatio sideris* sarebbe avvalorata dal fatto che la cerimonia di purificazione avviene in un giorno in cui la luna non è ancora visibile. Tuttavia, non in un giorno qualsiasi, bensì nel giorno esatto di novilunio, ovvero — come Dione ha cura di precisare — "prima che la luce della luna si mostri agli uomini" (πρὶν ἐς ὄψιν τοῖς ἀνθρώποις τὴν σηλήνην ἐλθεῖν) (2000: 53). L'atto di adorazione sarebbe dunque *intenzionale*, nel senso di supporre, nell'elefante, anche la facoltà di prevedere che la luna si renderà di lì a poco visibile.

4. CONCLUSIONE

Le due immagini di cui abbiamo parlato, quella del carro trionfale trainato dagli elefanti e quella della leggenda della venerazione della luna, sono indici minimi ma significativi del mutamento di certi costumi e di certe credenze verificatosi a Roma sul finire della Repubblica, in particolare durante il periodo di Silla e Pompeo Magno. Dall'Asia Minore, dalla Siria e dall'Egitto giunsero a Roma ambasciatori di un sapere nuovo di origine orientale integratosi facilmente nel tessuto della civiltà romana. In virtù di tale sincretismo religioso entrarono a far parte del pantheon nuovi dei, ma anche un particolare interesse per l'astrologia, l'astronomia e la magia; un ricco patrimonio acquisito attraverso le vie del commercio, le migrazioni, l'opera di poeti e scrittori, e persino i contatti militari che i Romani ebbero con popoli limitrofi. La ricerca di una esasperata magniloquenza nella proiezione dell'immagine del potere, l'attrazione per miti e culti esotici, nonché un'eclettica curiosità scientifica furono le condizioni che facilitarono la ricezione e l'elaborazione di un'immagine dell'elefante che, per il tramite della cultura latina medievale e rinascimentale, giunge fino a noi.

5. BIBLIOGRAFIA

Dione Cassio 2000. *Storia romana*, vol. II. Milano: Rizzoli.

Durand, G. 1972. *Le strutture antropologiche dell'Immaginario*. Bari: Dedalo.

Eliano 1998. *La natura degli animali*, vol. I. Milano: Rizzoli.

Momigliano, A. 1933. Ancora sul culto degli elefanti per la luna. In *Atheneum. Studi periodici di Letteratura e Storia dell'Antichità* XI: 267-268.

Pais, E. 1918. *Dalle guerre puniche a Cesare Augusto.* Roma: Nardecchia.

Passerini, A. 1933. L'origine del tradizionale culto degli elefanti per la luna. In *Atheneum. Studi periodici di Letteratura e Storia dell'Antichità* XI: 142-149.

Plinio 1982. *Storia naturale*. Torino: Einaudi.

Svetonio 1974. *Le vite dei dodici Cesari*. Milano: Rusconi.

The World of Elephants - International Congress, Rome 2001

Gli elefanti di Annibale nelle monete puniche e neopuniche

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SUMMARY: This study is about elephant iconography in Punic and Neopunic Coinage. The elephant is shown for the first time on the Carthagian Coinage of the Iberian Peninsula between the 237 and 227 BC. Later, it is found again on the Sicilian and North-African coins where it became the symbol of the Numidian and Mauritanian nationalism.

1. INTRODUZIONE

L'iconografia dell'elefante è introdotta nella monetazione antica da Alessandro Magno come simbolo delle vittorie ottenute in Battria e India. In questa regione, infatti, il pachiderma era utilizzato come mezzo di trasporto e strumento di battaglia, la quale si considerava conclusa al momento della cattura dell'animale. La proposizione del tema sulle monete alessandrine assume, quindi, un evidente significato di conquista e affermazione di potere. Da questo momento, la raffigurazione dell'elefante come emblema dei successi militari rimane costante nella monetazione antica. In Occidente, la prima testimonianza del tipo è riferibile ad Agatocle in relazione alla spedizione in Africa nel 311 a.C. contro Cartagine (Fig. 1).

Fig.1 - Zecca di Ecbatane (221-187 a.C.). Tetradramma di Antioco III.

2. Monetazione Punica

In ambito punico l'elefante viene raffigurato per la prima volta sulle monete barcidi in argento coniate nella Penisola Iberica tra il 237 e il 227 a.C. Le emissioni rivestono un rilievo del tutto particolare nel panorama della produzione cartaginese del III sec. a.C., come del resto, complesso e strategicamente impegnativo è il programma politico perseguito da Cartagine nella regione. La testa imberbe con corona o la testa barbata con mazza di Eracle-Melqart raffigurata sul dritto della serie, da un lato si ispira alla tipologia dell'Eracle con leontè già adottata negli argenti siciliani del IV sec. a.C., dall'altro è un evidente riferimento all'ideologia alessandrina del ritratto idealizzato (Fig. 2).

Fig.2 - Zecca della Penisola Iberica (237-218 a. C.). Doppio Sheqel. Dritto testa di Eracle-Melqart con mazza.

Fig.3 - Zecca della Penisola Iberica (237-218 a. C.). Doppio Sheqel. Rovescio elefante guidato da cornac.

In questo ambito e come riferimento alla potenza militare di Cartagine impegnata nella Penisola Iberica si intende l'iconografia del rovescio con l'elefante da guerra guidato o meno dal cornac (Fig. 3).

Le fonti classiche riferiscono che già nelle operazioni militari in Sicilia della metà del III sec. a.C., i Cartaginesi impegnarono gli elefanti come "forza d'urto", mentre Diodoro e Polibio ne sottolineano l'impiego nella Penisola Iberica.

Allo stesso modo, riferibili ad un contesto punico sono le monete con al D/ testa maschile laureata e al R/ elefante del 213-210 a.C. attribuite, sia pure dubitativamente, alla zecca di Agrigento e posta in relazione con l'estremo tentativo da parte cartaginese di riconquistare la Sicilia.

Nelle emissioni fin qui ricordate, l'elefante rimane costantemente legato al significato alessandrino dell'iconografia come simbolo di vittoria militare, anche se l'animale raffigurato non è più l'elefante asiatico con le orecchie piccole, la schiena arrotondata, la fronte dritta con due convessità. Il pachiderma utilizzato da Cartagine e dai sovrani numidi è quello africano particolarmente numeroso nel territorio pianeggiante d'accesso alla catena dell'Atlante. Il dato emerge, tra l'altro, della descrizione di Plinio (5, 2-28) del Nord-Africa, nella quale confluiscono anche precedenti testi di Giuba II, in particolare le "storie" degli elefanti.

Problematica diversa è quella relativa alle monete italiche emesse durante la campagna di Annibale tra il 216 e il 211 a.C. nella Penisola. Di incerta attribuzione e datazione restano, infatti, le monetazione in bronzo e in argento con al rovescio l'elefante delle emissioni di Calatia, Capua e Atella e delle monete con al D/testa di negro, quasi certamente attribuibili a zecca etrusca del III-II sec. a.C. e messe in relazione con il passaggio di Annibale in Val di Chiana. Le monetazioni dei centri italici che si alleano con Annibale, infatti, non possono intendersi come puniche, anche se non mancano elementi di tale influenza.

3. MONETAZIONE NEOPUNICA

La tipologia, in ambito neopunico, passa maggiormente a rappresentare l'africanità. La divinità con le spoglie di elefante, in particolare, diventa l'emblema del nazionalismo numida e mauretano, come sulla serie in bronzo a leggenda latina e punica, con al dritto busto di Giano, risalente al regno di Bocco II (38-33 a. C.), anche se le monete a leggenda punica di Giuba I (60- 46 a.C.) e quelle a leggenda latina di Giuba II (15-23 d. C.) mantengono entrambe le figurazioni simboliche.

4. CONCLUSIONI

In conclusione, sono interessanti alcune considerazioni: le divinità con spoglie di elefante, presenti già sulle monetazioni alessandrine, sono completamente assenti sulle emissioni puniche; l'animale rappresentato sia sulle monete puniche sia sulle neopuniche è costantemente del tipo africano. Tali osservazioni sono cariche di significati ideologici: Cartagine, pur sottolineando il controllo sull'Africa e le sue potenzialità militari, non esalta l'africanità dello stato, che diversamente sarà il motivo principale delle monetazioni dei regni e città autonome neopuniche.

5. BIBLIOGRAFIA

Acquaro, E, Manfredi, L.I. & Tusa Cutroni, A. 1991. *Le monete puniche in Italia*. Roma: Istituto Poligrafico e Zecca dello Stato.

Babelon, E. 1896. L'éléphant d'Annibal. *Revue de Numismatique*: 1-13.

Conti, O. 1998. Gli elefanti e il potere. *Cronaca numismatica* 102: 61-67.

Gowers, W. & Schullard, H.H. 1950. Hannibal's Elephants again. *Numismatic Chronicle*: 271-283.

Manfredi, L.I. 1995. *Repertorio epigrafico e numismatico delle leggende puniche.* Roma: Istituto Poligrafico e Zecca dello Stato.

Schullard, H.H. 1948. Hannibal's Elephants. *Numismatic Chronicle*: 158-168.

Sirago, V. A. 1996. Il contributo di Giuba II alla conoscenza dell'Africa. In M. Khanoussi *et al.*(eds.), *L'Africa romana. Atti dell'XI Convegno di studio (Cartagine, 15-18 dicembre 1994)*: 303-316. Ozieri: Il Torchietto.

The elephants in Rome: history, legends and anecdotes

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SUMMARY: In this paper the problem that the findings of elephant bones raised in the past is briefly discussed: were these elephants fossil or actual? In fact not all researchers thought these elephants to be fossil. Father Pianciani counted the elephants that were imported in ancient Rome and the elephants captured to Carthaginians, to demonstrate that fossils had been discovered. The theory about the disappearance of these animals and the legends and anecdotes are also discussed.

1. INTRODUCTION

In the past, the finding of bones of exotic animals in the Rome area was not considered always interesting, even if these animals today do not live at this latitude. Probably this apparent indifference was due to the conviction that these bones were of animals imported by the ancient Romans. For this reason that, when in the Rome area elephant bones were found, people thought these bones pertained to the elephants imported by ancient Romans or to the elephants captured Hannibal.

It is curious, but this conviction even today is deep-rooted into the population. In fact, some years ago, during an excavation intended to recover *Elephas antiquus* bones near Rome, the inhabitants thought these bones were bones of Hannibal elephants.

2. THE ELEPHANTS OF ANCIENT ROME

Although Ciampini in 1689 described some giant bones found near Vitorchiano (Viterbo) classifying them as fossil bones of elephant (Clerici 1908), in the first half of the XIX century some researchers still thought it was not possible that fossil elephants could be found in Roman sediments. In fact these findings were considered jokes of nature or the product of fermentation, due to the resemblance of some fossilis with bones of living animals, and also sketches of organisms or life germs enclosed into the rocks (De Angelis D'Ossat 1942).

Father G. B. Pianciani, of the Jesus Company, professor of Natural Sciences in Viterbo, devoted some of his works to prove the true nature of these bones (1817, 1836). In the work of 1836, Father Pianciani counts the elephants that were imported in ancient Rome. He mentions 4 elephants captured to Pyrrhus by Curius Dentatus in 479 and the more than a hundred that Metellus captured to Carthaginians; in additions there were several elephants that Claudius Pulchrus, L. Lucullus and M. Lucullus imported for the battles in the arenas. There were also some emperors (Nero, Domitianus, Septimius Severus) who imported exotic animals, among which were also elephants. The pachyderms were very much appreciated also by the population. The elephants were bred, also with success. In fact, Father Pianciani quoted Columella, that stated "*Inter moenia nostra natos animadvertimus elephantes*" (within our walls elephants were born).

3. ACTUAL OR FOSSIL ELEPHANTS?

Another big problem was to demonstrate that these bones were fossilised. But how does one demonstrate it? The problem was undoubtedly considerable, also because Father Pianciani well knew that some had asserted that these bones were too recent and therefore that these bones were buried in historical time. On the other hand, analysing carefully some bones found near Magognano (Viterbo), he recognised that these bones were not too ancient. Besides he underlines that "è più che evidente dallo stato in cui si trovano rotte e disperse e dai frammenti e tritumi quasi tutti vulcanici, cui sono congiunte, che non sono di quadrupedi morti sul luogo, né sepolte da uomini caritatevoli, ma trasportate dalle acque, e da queste inviluppate di terre, ghiaja, e ciottoli." (because they are broken and scattered into volcanic sediments, it is clear that these bones were not buried by men but only floated down in a river, together with gravels and pebbles). Furthermore Father Pianciani rejects the assumption that "le acque hanno potuto condurre da'climi dell'Asia, e dell'Affrica nelle nostre contrade le spoglie indicate." (water had led these bones from Asia and Africa to our country). Then he concludes "che queste ossa sono veramente fossili."(that these bones are really fossils).

Finally Father Pianciani wonders: "qual sembra dunque che sia stata l'epoca, quale la causa del seppellimento delle nostre ossa?" (what is the age and why are these bones buried?). His answer is that the cause was "una grande, ma passeggiera inondazione" (a big but temporary flood). And this flood was "l'ultima rivoluzione del globo" (the last revolution of the globe), it is the Flood.

Still, Father Pianciani wonders for what reason these giant animals are not quoted in ancient literature or in legends if these bones were not buried by "quella grande catastrofe o anteriormente, ma vissuti in epoca meno antica" (the Flood or before, but lived in recent time)?

4. LEGENDS

Legends about fossil elephants are not numerous. The best known is the legend of the Cyclopes: the findings of bones of *Elephas falconeri* originated, probably in Sicily, the legend of giant men with only one eye.

However several legends about giant humans were probably produced from the findings of bones of enormous animals (Abel 1945).

The finding of fossil bones of elephant, in 1459 near Viterbo is very interesting: "Nel detto tempo fu trovato le ossa di uno animale grandissimo in quello della solfatara di Viterbo. E alcuni portavano per alicorno, ma i più diceuano alifante a tempo del Diluvio" (Near Viterbo were found the bones of an enormous animal. Some thought they were bones of alicornus, others the bones of an elephant that lived at the time of the Flood) (De Angelis D'Ossat 1942). The *Alicornus* was a mysterious monster, probably half wolf and half alicorn (a horse with wings and one horn on the head).

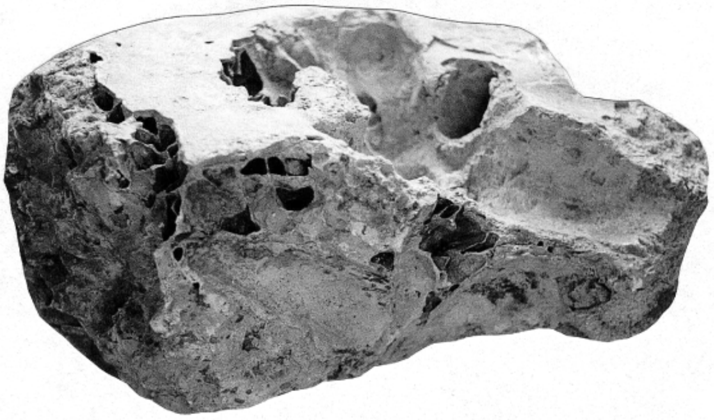

Fig.1 - Fragment of skull of a juvenile specimen of *Elephas antiquus*, found in Via dei Fori imperiali, Rome.

Fig.2 - Skull of *Elephas antiquus*, found at Montesacro, Rome, ventral view.

It is also interesting to underline the existence of another legendary animal: the *Odontotyrannus*.

But what is Odontotyrannus? *Odontotyrannus* was a monster characterised by three horns. It ate humans and lived in the Ganges river. Probably, the legend of this animal was born from the findings of tusks of elephants. Father Pianciani wrote (1836) that this animal was quoted for the first time by Aesophus, then by G. Valerio, Cedreno and Glica; Cedreno and Glica thought it was an amphibian, while Cuvier a mastodon.

Eichwald (1853) complicated this problem by describing some teeth of elephants as those of "*Elephas odontotyrannus*".

It is clear that about this legendary animal there was, and there is still now, a lot of uncertainty.

5. DISAPPEARANCE

Very interesting is a note that Ponzi expounded at the Pontifician Academy of Nuovi Lincei, in the 1862. In this scientific note he spoke about the geology of Central Apennines (Italy), and indirectly about the extinction of the elephants. It is important to underline that Ponzi considered all the elephant species to be of Pliocenic age and not Pleistocen age. The following text is a summary of Ponzi's opinion.

- In the Pliocene the elephants, together rhinos and hippopotamus, lived in the woods that covered a wide part of the Apennines. The climate was the same all over the earth, and very similar to that of the tropical areas.

At the end of the Pliocene, the earth cooled down so much that "le acque dei monti tutte si gelarono" (the waters froze in the mountains). Therefore the animals that were not able to live in these extreme climatic conditions, such as "*Elephas antiquus, E. meridionalis, E. primigenius, Hippopotamus major, Rhynoceros megarhynus*", died and were extinguished. Some other animals took refuge in caves; being so protected there lived as long as the temperature returned to acceptable values. Anyway, some of them died in these caves thus making the bone beds.

When the temperature increased, the climate was similar to the present one. Life grew again: "quel residuo di animali per avventura salvati nelle spelonche esce in libertà; con questi compariscono nuovi esseri, e la vita generale assume un carattere particolare attinente al nuovo ordine delle cose" (the animals came out from caves; new species appear and life submit itself to the new environments). The elephants lived only in the equatorial areas, where there is a hotter climate.

In the Apennines mountains, due to the increasing of the temperature, the ices thawed and "grandi correnti diluviane ebbero origine", "sbaragliando tutto ciò che incontrano" (produced devastating floods that destroyed every thing). Such floods produced enormous sedimentary deposits, as breccias where today it is possible to find several fossil bones

6. ANECDOTES AND CURIOSITIES

It is curious but sometimes tusks and bones were not recognised as such: for that reason these materials were thrown out!

Meli (1918), quotes a finding near the monastery of S. Pietro in Vincoli. In the year 1916, during the excavation of a hole, there were found some bones and teeth of an elephant. Initially the workers considered such materials as stones and then some were piled up in the ground, others thrown into the same hole. Only two years later (April 1918) a bricklayer showed Meli part of a tusk, thinking it was a putrefied trunk of a tree. Immediately Meli realised that this "trunk" was in reality a fragment of a tusk; so he was accompanied by the bricklayer to the hole and recovered the other parts of the tusk and the teeth. These parts of elephant were classified by Meli as "*Elephas africanus*".

An other curiosity is the argument between Tuccimei and Clerici (see Clerici 1891) about the age in which lived "*E. meridionalis*". In fact, Tuccimei (1891) thought that "*E. meridionalis*" lived in the Pliocene while Clerici (1888) considers it belonging to Pleistocene.

Tuccimei, in his work of 1891 attacks and criticises Clerici, since he thinks it is not possible to find *Corbicula fluminalis* together with "*E. meridionalis*", Clerici (1891) counterattacks Tuccimei and demonstrates by quoting several Authors, that *Corbicula fluminalis* is found together with "*E. meridionalis*". The quarrel is based on fossil material found at Rome and in the area around Rome and, due to the style of their quarrels, can be argued that Tuccimei and Clerici were not friends.

Finally a curiosity. Few people know that during the building of the Monument to Vittorio Emanule II, while excavating the foundations for the penultimate pillar (east side), at 14 meters of depth, was found a giant skeleton of elephant. This excavation cut the skeleton, damaging it. After a check, this skeleton was not excavated, because it was too expensive and because it required a lot of time (Antonioni 1970)! It is important to underline that this finding was located about fifty meters from the Campidoglio, in downtown Rome.

7. CONCLUSIONS

Today we smile when we read scientific papers written about a century ago. In fact in these recent years scientific progress has been very rapid.

Once those who thought that elephants lived in Italy, were considered almost heretic. Father Pianciani, in order to demonstrate that the bones found were fossils, had to count also the Pyrrhus's and Hannibal's elephants! Now we all know that elephants lived also in Italy and then at Rome. Anyway, the finding of a skeleton of elephant still arouses among students great emotions.

8. REFERENCES

Abel, O. 1945. *Animali del passato*. Mondadori.

Aichwald, E. 1853. Lethaea Rossica ou Paléontologie de la Russie. Dernière période. *Lethaea Rossica ou Paléontologie de la Russie* 13: 1-533.

Antonioni, L. 1970. *Roma inizio di secolo. Cronache vissute della Roma Umbertina*. Ed. mediterranee.

Clerici, E. 1888. Sulla *Corbula fluminalis* dei dintorni di Roma e sui fossili che l'accompagnano. *Boll. Soc. Geol. It.*, 5: 105-128.

Clerici, E. 1891. Sul *Castor fiber*, sull'*Elephas meridionalis* e sul periodo glaciale nei dintorni di Roma. (Risposta alle osservazioni critiche del dott. Tuccimei). *Boll. Soc. Geol. It.* 10: 333-370.

Clerici, E. 1908. Appunti per una escursione geologica a Viterbo. *Boll. Soc. Geol. It.* 27: 311-336.

De Angelis D'Ossat, G. 1942. Elefanti nella regione romana. *L'Urbe* 7, 8: 1-14.

Meli, R. 1918. Rinvenimento di resti fossili di un elefante nell'interno della città di Roma. *Att. Pontif. Acc. Rom. Nuovi Lincei* 71: 141-149.

Pianciani, G.B. 1817. *Delle ossa fossili di Magognano nel territorio di Viterbo*. A. Nobili Ed.

Pianciani, G.B. 1836. Di alcune ossa fossili rinvenute in Roma e ne' dintorni, e conservate nel museo kircheriano. *Giornale Arcadico* 67: 1-16.

Ponzi, G. 1862. Dell'Aniene e dei suoi relitti. *Att. Pontif. Acc. Rom. Nuovi Lincei*, 25: 327-356.

Tuccimei, G. 1891. Alcuni mammiferi fossili delle provincie Umbra e Romana. *Mem. Pontif. Acc. Rom. Nuovi Lincei* 7: 89-152.

Did endemic dwarf elephants survive on Mediterranean islands up to protohistorical times?

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SUMMARY: The wall paintings of the 18th Dynasty tomb of Rekh-mi-Rē, vizier of Thutmosis III, at Thebes (Egypt) show, among other figures, that of a small-sized elephant borne by the Syrian tributaries as a gift to the Egyptian pharaoh. It has been observed that this proboscidean cannot be an immature specimen in view of its large tusks, and that it could be referred to the Asiatic elephant, which seems to have lived in historical times in the western Near East. But, in the light of archaeological and paleontological evidence, it cannot be excluded that the elephant depicted in the Rekh-mi-R tomb could also represent a dwarf proboscidean, possibly imported to Egypt from somewhere in the Eastern Mediterranean islands where endemic dwarf elephants might still have survived up to protohistorical times.

1. INTRODUCTION

According to paleontological evidence, several Mediterranean islands have provided remains of Middle/Late Pleistocene proboscideans. These are Giglio (Tuscan archipelago), Sardinia, Favignana (Egadi islands), Sicily, Malta, Kythera, Euboea, Cyclades (Milos, Kythnos, Seriphos, Delos, and Naxos), Crete, Dodecanese islands (Rhodes, Tilos and Kos), Ikaria, Samos, Chios, Gökçeada (Imbros), and Cyprus (Kotsakis 1990, Masseti 1993, Caloi *et al.* 1996). Recently fossil elephant teeth have also been discovered on the island of Astypalaia (Dodecanese, Greece) (Maria Kollas, pers. com.). Most of these forms are reputed as endemic to the islands - they are often dwarf - and appear to derive from the straight-tusked elephant, *Elephas antiquus* Falconer & Cautley 1847, a species dispersed up to the Late Pleistocene in the western Palaearctic. It is generally believed that all these elephants became extinct in pre-Neolithic times. But, in the light of archaeological evidence, one of these forms should have survived further into the Holocene.

2. THE DWARF ELEPHANTS OF THE ISLAND OF TILOS (DODECANESE, GREECE)

Available evidence, in fact, records, the existence of dwarf elephants in relatively recent times in only one Mediterranean island, the island of Tilos (Dodecanese, Greece). Located between Rhodes and Kos in the Eastern Aegean sea, at about 20 km from the nearest point of the Anatolian mainland (Bozburun peninsula), this island was inhabited by an endemic fauna which was discovered in the cave of Charkadio and included dwarf elephant remains (Fig. 1). These proboscideans have been described as belonging to the genus *Elephas* (Symeonidis *et al.* 1973, Theodorou 1983, 1988), but are still specifically unnamed (Alcover *et al.* 1998). They have often been compared to *Elephas falconeri* Busk, 1867, a taxon described from Sicily and Malta (Ambrosetti 1968). The form is, however, slightly larger than the Sicilian pygmy elephant, whilst the age of the deposits of the discovery site ranges from the very late Pleistocene to the Holocene (Theodorou 1983, 1988). Two dates were obtained through the ^{14}C dating of the elephant bones: 7090+/- 680 and 4390 +/- 600 bp (Bachmayer & Symeonidis

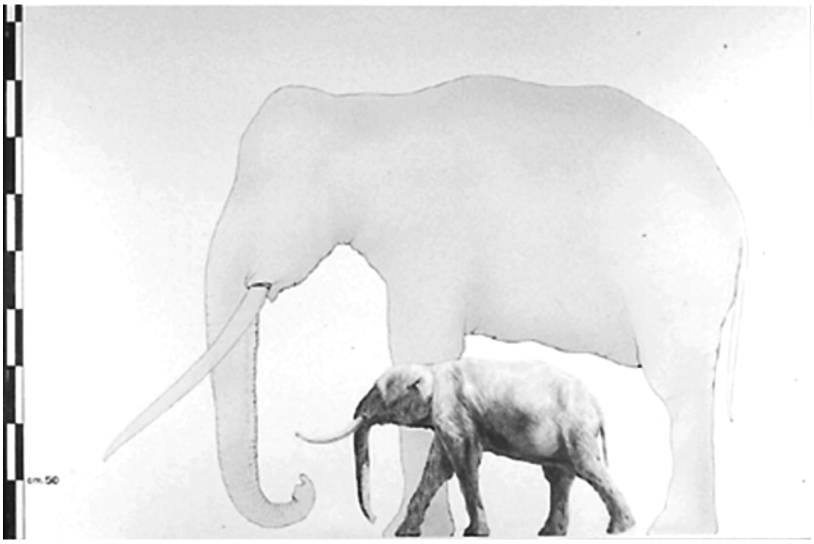

Fig.1 - Artist’s reconstruction of the extinct dwarf elephant, *Elephas antiquus* cf. *falconeri* Busk, 1867, of Late Pleistocene-Holocene Tilos, adapted from the osteological material in the Museum of Megalochorio (Tilos, Greece), and compared to the size of its supposed ancestor *E. antiquus* Falconer & Cautley, 1847 (drawing by A. Mangione).

1975, Bachmayer *et al.* 1976). These datings relate to different parts of the cave and appear to prove the simultaneous existence of the elephants and post-Palaeolithic man (Bachmayer & Symeonidis 1975, Bachmayer *et al.* 1976, Bachmayer *et al.* 1984). Furthermore, if such dating is reliable, we can presume this taxon survived at least until the beginning of the Aegean Bronze Age.

3. THE “PYGMY ELEPHANT” OF THE WALL PAINTINGS OF THE 18TH DYNASTY TOMB OF REKN-MI R , AT THEBES (EGYPT)

Several years ago, Rosen (1994) and White (1994) carried out a correspondence in the pages of *Nature* on the interpretation of the figure of a small-sized elephant depicted on the wall-paintings of the 18th Dynasty tomb of Rekh-mi-Rē, vizier of Thutmosis III and Amenhotep II (from about 1470 to 1445 BC) (cf. Davies 1935), at Thebes (Egypt) (Fig. 2). Sparked off by the assumption of Lister (1993) that Siberian dwarf mammoths lived up to the time of the Egyptian pharaohs, this correspondence led Rosen to suppose that the decoration effectively portrayed a dwarf mammoth, whereas White claimed that it was actually a small-sized African elephant. As already noted by the two correspondents, the image represents an adult specimen characterized by well developed tusks. According to other authors, such as Davies (1935), and Osborne & Osbornova (1998), it displays morphological patterns which might be referred to Asian elephants, *Elephas maximus* L., 1758, that possibly lived in the Near East at the time. According in fact to pictorial, written and osteological evidence, it seems that wild herds of proboscideans lived in the ancient land of Niya, located in western Syria, between the late second and early first millennium BC (Hatt 1959, Buitenhuis 1990, Gabolde 2000). Regarding the peculiar size of the elephant in the Egyptian painting, as far back as 1935, Davies N. de Garis remarked that the artists kept the animals small so that they would not dominate the tribute bearing procession, although the length of the tusks tends to suggest that they were thinking of an adult specimen. White (1994) and Osborne & Osbornova (1998), also noted that the differential scale of the human and animal

Fig.2 - Detail of the wall-painting of the tomb of Rekh-mi-Rē, at Thebes (Egypt), showing a small-sized elephant borne by the Syrian tributaries (photograph by N. Douek Galante).

figures is the result of stylistic convention rather than naturalistic representation (cf. Pirenne 1962, Aldred 1984). It can be observed, however, that this conventional Egyptian method of portraying the size of animal and human beings is not consistently adopted in the wall-decoration of the Rekh-mi-R tomb. The tusks of the portrayed specimen are in fact much smaller and inconsistent with those shown being carried by the Syrian to the right, and the Minoan and Nubian bearers pictured in other sections of the wall-painting (cf. Evans 1928). This incongruence contrasts with the representation of other animals in the same picture. For example, the giraffe portrayed with the Nubian bearers takes up the entire available vertical space of the register. It therefore seems arguable that rather than with evidence of the stylistic convention to which the artists had to conform, we may actually be dealing with the portrait of a dwarf elephant. But, as already observed, there is no fully convincing evidence for the identification with the morphology of an Asiatic elephant. Thus, it may be possible to trace the morphological characteristics of the proboscidean to geographical species closer to ancient Egypt, possibly even among the Mediterranean islands where paleontological evidence records the occurrence of dwarf and pygmy elephants from at least as far back as the Middle Pleistocene. But how could it come about that an insular dwarf elephant was brought to Egypt by Near-Eastern tributaries? How did they get hold of it? And which Mediterranean island did it originally come from?

4. CONCLUDING REMARKS

In the paintings of the Rekh-mi-R tomb, the Near-Eastern tributaries borne the small-sized elephant, together with other goods which were so clearly precious for the Egyptian market, that they could be offered to the pharaoh. In this contest, an adult dwarf elephant would have cut a fine figure. It value could have been related more to its curiosity appeal than to its effective economic worth, or even to both. On the other hand, there is considerable archaeological evidence for the circulation and trade of materials and ideas between the Mediterranean and south-eastern Asia. Cultural interaction between Crete, Cyprus, the Near East and Egypt increased markedly during the Late

Bronze Age (Stubbings 1951, Benzi 1996). The main maritime route connecting the Aegean to the Near East during the Bronze Age passed between Rhodes and the peninsula of Bozburun (Niemeier 1998), located a few marine miles off the northern coast of the island of Tilos. And the Minoan presence on Tilos and the other islands of the so-called "eastern Aegean string" is documented from at least ca. 2000-1800 BC onwards (Sampson 1983, Niemeier, 1998). This is not to say that the living proboscidean depicted in the Rekh-mi-R tomb is definitely the portrait of a Tilos elephant actually captured by the Aegean Bronze Age people on the island. It may have be a dwarf representative of the genus *Elephas* which survived on any Eastern Mediterranean island during the time of the Minoan-Mycenean control. It cannot be excluded that from this as yet unidentified island the dwarf elephant could have been exported to a mainland area where it could have represented a precious and rare curiosity to be exchanged as costly gift between Aegean, Near Eastern and Egyptian rulers. While hopefully awaiting a revised dating for the elephants of Tilos, further investigations are also needed to better understand the significance of the Egyptian painting.

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6. REFERENCES

Alcover, J.A., Campillo, X., Macias, M. & Sans, A. 1998. Mammal Species of the World: Additional data on Insular Mammals. *American Museum Novitates* 3248: 1-29.

Aldred, C. 1984, *Egyptian art*. London: Thames and Hudson Ltd.

Ambrosetti, P. 1968. The Pleistocene dwarf elephants of Spinagallo (Siracusa, South-Eastern Sicily). *Geol. Rom.* 1: 217-229.

Bachmayer, F. & Symeonidis, N. 1975. Eigenartige Abspaltungen von Stosszähnen der Zwergelefanten aus der Höhle "Charkadio" auf der Insel Tilos - Artefakte?. *Annales Géologiques des Pays Hélleniques* 26: 320-323.

Bachmayer, F., Symeonidis, N., Seeman, R. & Zapfe, H., 1976. Die Ausgrabungen in der Zwergelefanten "Charkadio" auf der Insel Tilos (Dodekanes, Griechenland) in den Jahren 1974 und 1975. *Ann. Naturhistor. Mus. Wien* 80: 113-144.

Bachmayer, F., Symeonidis, N. & Zapfe, H. 1984. Die Asgrabungen in der Zwergelefantenhöle der Insel Tilos (Dodekanes, Griechenland) im Jahr 1983. *Sitzungsberichten der Österreichischen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Kl.* Abt. I 193: 321-328.

Benzi, M. 1996. Problems of the Mycenean expansion in the South-Eastern Aegean. In De Miro, E., Godart, L. & Sacconi, A. (eds.), *Atti e Memorie del Secondo Congresso Internazionale di Miceneologia*. Gruppo Editoriale Internazionale, Roma: 947-978.

Buitenhuis, H. 1990. Archaeozoological aspects of Late Holocene economy and environment in the Near East. In Bottema, Brentjes & Van Zeist (eds.), *Man's role in the shaping of the Eastern Mediterranean landscape*: 195-205. Balkema, Rotterdam.

Caloi, L., Kotsakis, T., Palombo, M.R. & Petronio, C., 1996. The Pleistocene dwarf elephants of mediterranean islands. In Shoshani, J., Tassy, P. (eds.), *The Proboscidea*. 234-240. Oxford/New York/Toronto: Oxford University Press.

Davies, N. de Garis, 1935. *Paintings from the Tomb of Rekh-mi-R at Thebes*. The Metropolitan Museum of Art, Egyptian Expedition. 9 pp, XXVI plates, New York: Platin Press.

Drower, M.S. 1973. Syria ca. 1550-1400 BC. *In Cambridge Ancient History*. 3rd ed. II/I:

417-525. Cambridge: Cambridge University.

Evans, A. 1928. *The Palace of Minos at Knossos*, II/II. London.

Gabolde, M. 2000. Les elephants de Niyi d'apres les sources egyptiennes. In Béal, J.-C. & Goyon, J.-C. (eds.), *Des ivoires ate des cornes dans les mondes anciens (Orient-Occident)*: 129-139. Université Lunière-Lyon 2.

Hatt, R.T. 1959. The mammals of Iraq. *Misc. Publs Mus. Zool. Univ. Mich.* 106: 1-113.

Kotsakis, T. 1990. Insular and non insular vertebrate fossil faunas in the Eastern Mediterraenan islands. *Atti dei Convegni Lincei* 85: 289-334.

Lister, A.M. 1993. Mammoths in miniature. *Nature* 362: 288-289.

Masseti, M. 1993. On the Pleistocene occurrence of *Elephas (Palaeoloxodon) antiquus* in the Tuscan Archipelago, northern Tyrrhenian Sea (Italy). *Hystrix,* 5 (1-2): 101-105.

Niemeier, W.-D. 1998. The Minoans in the South-Eastern Aegean and Cyprus. In Karageorghis V. & Stampolidis N. (eds.), *Eastern Mediterranean: Cyprus-Dodecanese-Crete 16th-6th cent.* BC: 29-47. Nicosia: The University of Crete, Rethymnon, and the A.G. Levendis Foundation.

Osborne, D.J. & Osbornova, J. 1998. *The mammals of ancient Egypt*. Warmister: Aris & Phillips Ltd.

Pirenne, J. 1962 – *Histoire de la Civilisation de l'Egypte Ancienne.* Neuchâtel: Editions de la Baconnière.

Rosen, B. 1994. Mammoths in ancient Egypt? *Nature* 369: 364-365.

Sampson, A. 1983. Topographical survey of prehistoric sites in the Dodecanese. In Keller D.R. & Rupp D.W. (eds.), Archaeological survey in the Mediterranean area. *BAR International Series* 155: 283-285.

Stubbings, F.H. 1951. *Mycenean Pottery from the Levant*. Cambridge.

Theodorou, G.E. 1983. *Die fossilen Zwergelefanetn der Höhle "Charkadio" auf der Insel Tilos*. Athens: Dodekanes. Dissertation Univ.

Theodorou, G.E. 1988. Environmental factors affecting the evolution of island endemics: the Tilos example from Greece. *Modern Geology* 13: 183-188.

White, W. 1994. Painted out. *Nature* 370: 604.

L'Arco di Domiziano con quadrighe di elefanti

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SUMMARY: Three coins of emperor Domitian show the picture of an arch: a Janus carrying two *quadrigae* with elephants standing over. This monument is traditionally identified with the *Porta Triumphalis*, commemorated by Martialis nearby the temple of *Fortuna Redux in Rome*. A series of imperial relieves of triumphal context also shows the arch, characterized by elephants, connected with the temple of *Fortuna Redux*. As chariots with elephants were reserved to the emperors, overall in imperial apotheosis, the use of two *quadrigae* suggest the interpretation of the arch as a monument built by Domitian in honor of *divi* Vespasianus and Titus, recalling their famous triumph over the Judies.

1. INTRODUZIONE

Tra i non numerosi monumenti raffigurati nella monetazione di Domiziano ne risalta uno che compare per ben tre volte, su sesterzi dell'85, del 90 e del 95 d.C. (BMC II, Dom. n. 303† : 364; n. 443*: 399 e n. 476† : 407); si tratta di un arco, anzi un giano, sormontato da due quadrighe di elefanti, il cui studio e la cui interpretazione sono stati sempre fortemente condizionati dall'identificazione con l'arco ricordato da Marziale come *porta digna tuis triumphis*, cioè con la Porta Trionfale. L'interesse che quest'ultimo monumento ha sempre creato intorno a sé, sul problema della sua localizzazione e della definizione del percorso della *pompa triumphalis*, ha un po' deviato l'attenzione dall'arco raffigurato sulle monete, che vengono quindi utilizzate solo come fondamento documentario ormai certo ed acquisito.

2. L'ARCO DELLE MONETE

Molti dati si possono invece ricavare da un'attenta analisi del monumento raffigurato sul rovescio delle monete, sempre lo stesso, definito con più o meno particolari, tra le lettere S(*enatus*) C(*onsulto*).

Soprattutto alcuni esemplari del 90 e del 95 d.C. offrono una descrizione piuttosto precisa: non sembrano esserci dubbi sul fatto che si tratti di un giano, vista la precisa resa dell'angolo tra i due fornici; il fornice su ciascuno dei lati è affiancato da due coppie di colonne su alto podio, che giungono fino all'attico; negli estradossi, sopra i fornici, è una cornice circolare che pare contenere un ritratto (soprattutto nel medaglione di sinistra, meglio visibile, si riconosce la parte superiore di una figura umana, facendo quindi individuare il motivo delle *imagines clipeatae*). Sull'attico, piuttosto alto, sono dei pannelli rettangolari a rilievo, in corrispondenza con i fornici, raffiguranti quello di sinistra forse una scena di sacrificio, con due figure stanti ai lati di un altare sul quale brucia la fiamma. Nel pannello di destra è una scena di più difficile lettura, sempre con due figure, una di fronte all'altra, quella più a destra sicuramente seduta.

Nei diversi coni le scene sembrano sempre le stesse, per cui o l'arco veniva raffigurato sempre dallo stesso punto di vista oppure, meno probabilmente, le scene si ripetevano uguali sulle facciate corrispondenti. Ai due lati di ciascun rilievo è una figura umana stante, sembra a tutto tondo, probabilmente un prigione o un trofeo. Sopra l'attico sono poi due quadrighe volte in direzioni opposte, ciascuna guidata da un suo auriga, trainate da quattro elefanti.

Il giano è stato identificato dagli studiosi

Fig.1 - Sesterzio di Domiziano del 90 d.C. raffigurante l'arco.

sulla scorta di un epigramma di Marziale (VIII, 65, datato al 93 ca.), il quale, riferendosi ad un trionfo di Domiziano, descrive un arco trionfale sormontato da due quadrighe di elefanti e lo associa topograficamente al tempio di *Fortuna Redux*, divinità posta a tutela del ritorno (*adventus*) e del trionfo dell'imperatore. Lo stesso monumento è stato riconosciuto sul rilievo aureliano dell'arco di Costantino con scena di *profectio* (Koeppel 1986: 56-58, fig.31, n.26) e, in associazione con il tempio della *Fortuna Redux*, su monete di Marco Aurelio del 173-174 d.C. con scena di *adventus* (Gnecchi 1912: 27, nn.2-3, tav.59,5), sul rilievo aureliano dell'arco di Costantino ancora con scena di *adventus* (Angelicoussis 1984: 151, tav. 66,1; Koeppel 1986; 70-72, figg.37-38) e sul rilievo di Marco Aurelio al Palazzo dei Conservatori con rappresentazione di trionfo (Angelicoussis 1984: 152-154, tav.66,2; Koeppel 1986: 50-52, tav.28). Secondo alcuni studiosi (Stuart Jones 1906: 260-263; Hommel 1954: 45; Champeaux 1982: 267, n.92), l'arco citato da Marziale va identificato con la *Porta Triumphalis*, che Domiziano, in occasione di uno dei suoi trionfi, avrebbe ricostruito nel Campo Marzio dopo l'incendio dell'80 d.C., innalzando nello stesso tempo un tempio dedicato a *Fortuna Redux*; gli stessi studiosi ipotizzano inoltre per i due edifici una ubicazione nel Campo Marzio centrale. Filippo Coarelli (Coarelli 1968: 57-69 e 1988: 381, 400-401, 456-459) ha invece proposto per la *Porta Triumphalis* una ubicazione nel Foro Boario, nei pressi della *Porta Carmentalis*, che sorgeva sotto le pendici meridionali del Campidoglio in corrispondenza del *vicus Iugarius*; Coarelli ritiene inoltre che, come già ipotizzato dal Colini (Colini 1940: 75-76), il tempio di *Fortuna Redux* vada identificato con quello più occidentale dei templi gemelli dell'area sacra di S. Omobono, da sempre attribuito a Fortuna, senza altri attributi.

Lo studio di un rilievo storico dell'Antiquarium Comunale con rappresentazione del frontone del tempio di *Fortuna Redux*, rinvenuto nei pressi dei templi di S. Omobono nel 1938, sembra confermare l'identificazione del tempio stesso, e quindi l'ubicazione della *Porta Triumphalis* in una zona molto vicina (Loreti 1996), anche se ancora non sicuramente identificabile (la proposta di identificazione avanzata da G. Ioppolo in Coarelli 1988: 439-442, che utilizzando alcune strutture in cementizio rinvenute al centro dell'area sacra di S. Omobono ricostruisce un doppio giano molto allungato, sembra infatti poco verosimile in raffronto con l'arco ricostruibile dalle monete).

L'identificazione con la *Porta Triumphalis* e le problematiche legate alla collocazione topografica del giano rappresentato sulle monete di Domiziano hanno finora deviato l'attenzione dallo studio del monumento ricostruibile da monete e rilievi e dal suo apparato iconografico. Questo appare piuttosto ricco, con elementi caratterizzanti e non del tutto usuali per un arco (come ad esempio le *imagines clipeatae*), ai quali si deve quindi sicuramente attribuire un significato simbolico importante, visto che si è ritenuto opportuno segnalarli anche nelle piccole dimensioni di una moneta.

Di particolare interesse è la presenza sull’attico di ben due quadrighe condotte da elefanti, che costituiscono infatti un soggetto piuttosto raro, e per il tipo di animale prescelto e per il raddoppiamento delle quadrighe. A partire dal ricordo del ritorno di Alessandro Magno in Egitto su un carro tirato da elefanti, che richiama l’analogo ritorno dall’India di Dioniso, l’elefante come animale da traino appare soprattutto in età imperiale a partire da Augusto, e sembra comunque sempre riservato all’imperatore o ai suoi stretti familiari. Oltre la biga trainata da elefanti su cui è Augusto in un denario del 18 a.C. (*BMC* I, Aug. n. 52-4) e in un *aureus* dl 17-16 a.C. (*BMC* I, Aug. n. 432 QUOD VIAS MUN[ITAE] SVNT), la prima quadriga tirata da elefanti compare su un sesterzio di Tiberio del 34 d.C. (*BMC* I, Tib., nn. 102, 108. 125) e si può riferire all’ambito della *pompa circensis*, durante la quale venivano fatti sfilare carri trainati da elefanti che portavano le immagini degli imperatori defunti e divinizzati. Questo onore è attestato anche per Livia (Suet., Claud. 11,2), per Augusto e Claudio in monete neroniane *(BMC* I, Ner., nn. 7-8), per Vespasiano su sesterzi di Tito (*BMC* II, Tito, nn. 221-223) e per Giulia, figlia di Tito, su aurei domizianei (*BMC* II, Dom., n. 250†). E’ evidente quindi la connessione dell’elefante con la figura dell’imperatore, unico del resto che aveva diritto di possederne (Juv. Sat. XII, 106), ma soprattutto con l’imperatore divinizzato, con l’apoteosi imperiale. Non va inoltre trascurata la trasposizione del simbolismo trionfale connesso all’immagine dell’elefante in contesto funerario, che porta all’utilizzazione dell’immagine di elefanti anche su sarcofagi (Musso 1993: 15-17).

Che una quadriga di elefanti fosse un fastigio insolito per un arco ma non un caso eccezionale è confermato dalle raffigurazioni di archi simili sia nel famoso rilievo Torlonia, che rappresenta il porto di Ostia, sia in un sarcofago dei Musei Vaticani con veduta di porti (Meiggs 1973: 158ss.).

La duplicazione delle quadrighe sull’arco delle monete appare comunque inconsueta, e non si può certo spiegare con un duplice trionfo di Domiziano, visto che ogni quadriga ha il suo guidatore; sembra invece più probabile pensare ad un trionfo di due persone: l’immediato richiamo è quello del trionfo più noto e reclamizzato dell’epoca, quello di Vespasiano e Tito sui Giudei. Il ricordo del trionfo sui Giudei, al quale anche Domiziano aveva partecipato, si può forse vedere anche nel rilievo con scena di sacrificio nell’attico dell’arco, che potrebbe ricordare quello offerto da Vespasiano e Tito agli dei della Porta Trionfale (ricordato da Flavio Giuseppe, *B.Jud.* VII, 5,4).

3. CONCLUSIONI

In base all’analisi dell’apparato decorativo dell’arco raffigurato sulle monete, con valenze insieme onorarie e funerarie (1. *imagines clipeatae* = ritratti degli avi distintisi per valore; 2. prigioni o trofei= simbolo di vittoria militare; 3. quadrighe di elefanti = apoteosi imperiale) sembra possibile che nel ricostruire la Porta Trionfale Domiziano, del quale è nota la cura posta nella diffusione del culto e del ricordo di padre e fratello divinizzati, abbia voluto elevare un monumento a Vespasiano e Tito divinizzati e trionfanti. Il fatto che esso non fosse connesso esclusivamente alla figura dell’imperatore spiegherebbe anche la sopravvivenza dell’arco, identificabile con la Porta Trionfale, alla *damnatio memoriae* di Domiziano.

4. BIBLIOGRAFIA

Angelicoussis, E. 1984. The Panel Reliefs of Marcus Aurelius. *Römische Mitteilungen* 91: 141-205

BMC I = Mattingly, H. 1930. *Coins of the Roman Empire in the British Museum,* I. London.

BMC II = Mattingly, H. 1930. *Coins of the*

Roman Empire in the British Museum, II. London.

Champeaux, J. 1982. *Fortuna. Recherches sur le culte de la Fortune à Rome et dans le monde romani des origins à la mort de César*. Roma.

Coarelli, F. 1968. La Porta Trionfale e la Via dei Trionfi. *Dialoghi di Archeologia* 2: 55-103.

Coarelli, F. 1988. *Il Foro Boario*. Dalle origini alla fine della Repubblica. Roma.

Coarelli, F. 1995. s.v. *Fortuna Redux, ara e templum*. In M.E. Steinby (ed.), *Lexicon Topographicum Urbis Romae*. II. Roma.

Colini, A. 1940. L'Area Sacra di S. Omobono. *Bullettino della Commissione Archeologica Comunale di Roma* 68: 75-76.

Gnecchi, F. 1912. *I medaglioni romani*. Milano.

Hill, Ph.V. 1989. *The Monuments of Ancient Rome as Coins Types*. London.

Hommel, P. 1954. *Studien zu den romischen Figurengiebeln der Kaiserzeit*. Berlin.

Koeppel, G.M. 1985. Die historischen Reliefs der romischen Kaiserzeit III. Stadtrömische Denkmaler unbekannter Bauzugehorigkeit aus trajanischer Zeit. *Bonner Jahrbucher* 185: 143-214.

Koeppel, G.M. 1986. Die historischen Reliefs der romischen Kaiserzeit IV. Stadtrömische Denkmaler unbekannter Bauzugehorigkeit aus hadrianischer bis konstantinischer Zeit. *Bonner Jahrbucher* 186: 1-90.

Loreti, E.M. 1996. Rilievo storico dall'area sacra di S. Omobono. *Bullettino della Commissione Archeologica Comunale di Roma* 97: 243-254.

Meiggs, R. 1973. *Roman Ostia*. Oxford.

Musso, L. 1993. Frammento di sarcofago con elefante. In A. Giuliano (ed.), *Museo Nazionale Romano* I, 10*: 15-17.

Platner, S.B. & Ashby, Th. 1929. *A topographical dictionary of ancient Rome*. Oxford.

Richardson, L. 1992. A New *Topographical Dictionary of Ancient Rome*. Baltimore.

Scott Ryberg, I. 1955. *Rites of State Religion in Roman Art, Memoirs of the American Academy at Rome,* 22.

Engraved, painted and carved mammoths of the Rhône basin (Upper Palaeolithic)

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Mammoths have been depicted in the Rhône basin by prehistoric hunter-gatherers since the Aurignacian, and mostly so from Solutrean to middle Magdalenian times, as it can be seen at a dozen sites (Gard, Ardèche and Bourgogne regions). The record includes parietal art (engravings and paintings), as well as portable art (bone and stone engravings, and even an unpublished statuette from Solutré). The many palaeontological remains of this proboscidean, also discovered in the area, further suggest a long and continuous coexistence. Some very schematic figures, however, point to the fact that this species had a special place in collective imagery, and probably in *Homo sapiens sapiens* ritual activity as well.

Tools from elephant bones at La Polledrara di Cecanibbio and Rebibbia-Casal de' Pazzi

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SUMMARY: The two Pleistocene deposits of La Polledrara and Rebibbia-Casal de' Pazzi, located in the "Campagna Romana", show some similarities in the geological setting and in the modality of accumulation of bones and lithic industry. The presence of bone tools confirms a peculiar characteristic of artifact production at the Pleistocene sites of the Latium region.

1. La Polledrara

The excavations of the Middle Pleistocene deposit of La Polledrara di Cecanibbio, undertaken between 1985-1999, have uncovered about 750 square metres of a paleosurface belonging to an ancient stream bed dissecting a leucitic granular tuffite bank. The deposit is included within the terminal series of the pyroclastic deposits of the "Sabatino" volcanic complex and has been associated with the "Aurelian Formation", correlated with OIS 9.

The palaeosurface was covered irregularly by a large number of faunal remains (so far over 9000 finds), particularly of *Elephas antiquus* and *Bos primigenius*, which accumulated in various levels in the deepest part of the stream bed and which are scattered within a single level in the marginal areas. The bone assemblage shows varying states of surficial preservation: highly abraded bones are very numerous; a few bones are fresh in appearance or have only minor traces of abrasion; sometimes only the exposed surface of the bone shows traces of weathering, whereas the surface of the bone in contact with the paleosurface is unaltered.

A more recent phase, characterized by the obliteration of the watercourse and the formation of a marshy environment, has been revealed during the latest archaeological campaigns. The bones from this layer have very fresh surfaces; the partially articulated skeletons of two elephants (*Elephas antiquus*) and one wolf (*Canis lupus*) have also been recovered from this layer.

The bones were embedded in a light grey ashy tuffite and were fossilized by their transformation into fluoroapatite - a resistant material linked to post-volcanic gaseous activity.

The bone assemblage varies greatly not only in the state of the surface preservation, but also in various degrees of fragmentation. One of the aims of the taphonomic analysis of the deposit, currently in progress, is to clarify the various processes of bone fragmentation, for example, environmental conditions, trampling by animals, carnivore and human activity. The presence of a lithic industry made from small siliceous pebbles in association with the bones, testifies the presence of humans at the site.

The presence of humans is also documented at La Polledrara and in other Middle Pleistocene deposits of the Latium region (Castel di Guido and Fontana Ranuccio), by indubitable tools made from fragments of long bones of elephant.

The difficulty of obtaining raw materials in this volcanic area for the production of large-sized lithic tools has certainly contributed to the development of this kind of bone artifact production.

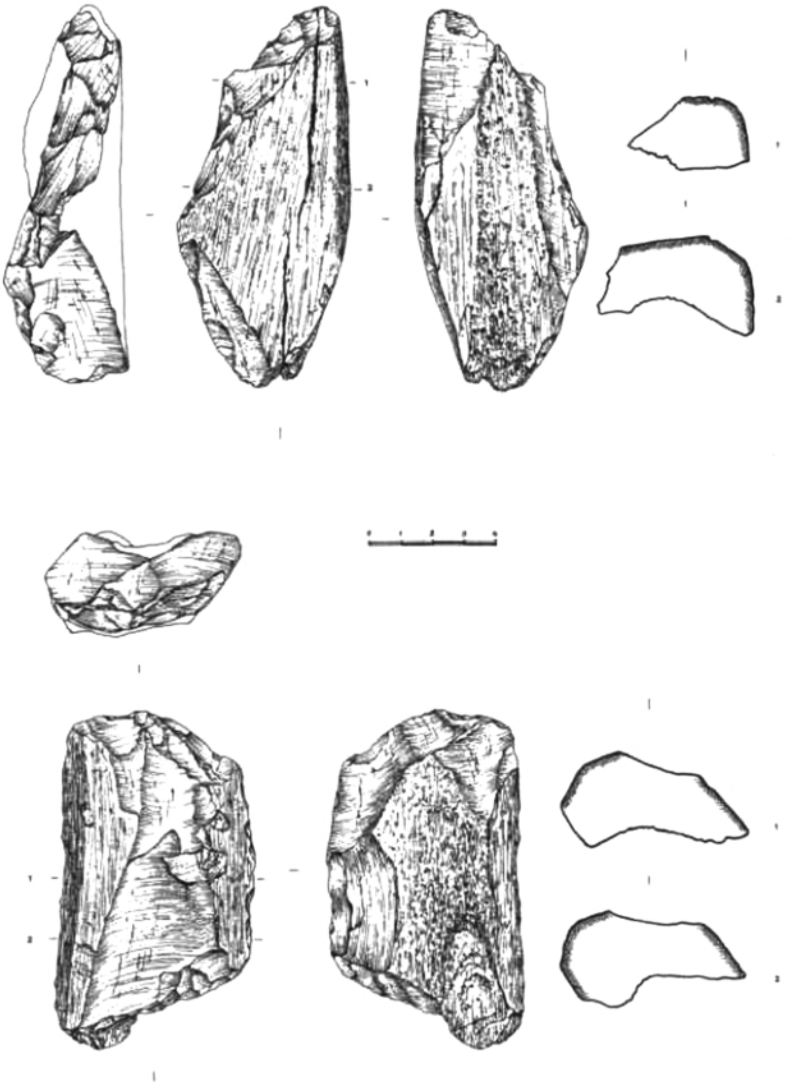

Fig.1 - Bone tools from La Polledrara.

In contrast to the neighbouring Pleistocene deposit of Castel di Guido, where numerous unambiguous Acheulean bifaces made of elephant bone are present, only a few artifacts (a total of eight so far) were identified at la Polledrara di Cecanibbio. The tools, selected from about 9000 faunal remains, comprise scrapers, denticulates as well as artifacts with truncated ends with multiple unifacial or bifacial scars (Fig. 1). The edges of scrapers and denticulates were modified by continuous retouch producing flake scars with negative bulbs of percussion. These traces are usually located on the cortical face of the finds. In addition to deliberately worked bone tools, flakes produced from the diaphyses of elephant bones with a striking platform and a bulb of percussion similar to those observed on lithic flakes have been identified at la Polledrara. Further, fragments of long bones were recovered with a few unidirectional removals subsequent to primary fracture, probably resulting from the utilization of these pieces as tools by humans.

The presence at la Polledrara of such a large number of bovid and elephant carcasses suggests that humans frequented the site during their scavenging or butchering activities, and also with the intention of exploiting accumulations of bone for tool making.

2. Rebibbia - Casal De' Pazzi

Between 1981-1986 archaeological researches in the suburbs of Rome on the middle terrace of the valley of the river Aniene, revealed a segment of an ancient river channel cut into the "Tufo litoide lionato" layer, belonging to the "Vulcano Laziale" complex. In the infill of gravel and sand, over 2000 faunal remains, mainly *Elephas*, *Bos*, *Hippopotamus* and *Cervus*, were discovered in association with some 1500 lithic tools made of small siliceous pebbles, and a fragment of a parietal bone attributable to an ancient form of *Homo sapiens*.

The deposit has been correlated with OIS 7, and belongs to the sedimentary cycle called "Vitinian".

The presence of bone tools is testified by only one clear implement made from a fragment of the diaphysis of a long bone of elephant. The tool has a truncated end and a few unidirectional flake scars (Fig. 2).

3. References

Anzidei, A.P., Angelelli, F., Arnoldus Huyzendveld, A., Caloi, L., Palombo, M.R., Segre, A.G. 1989. Le gisement pléistocène de La Polledrara di Cecanibbio (Rome, Italie). *L'Anthropologie* 93: 749-781.

Anzidei, A.P., Arnoldus Huyzendveld, A. 1992. The Middle Pleistocene site of La Polledrara di Cecanibbio (Rome, Italy). In *Papers of the Fourth Conference of Italian Archaeology. New Developments in Italian Archaeology, part I*: 141-153. London: Accordia Research Centre.

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Mussi, M., Palombo, M.R. in press, Nouvelles

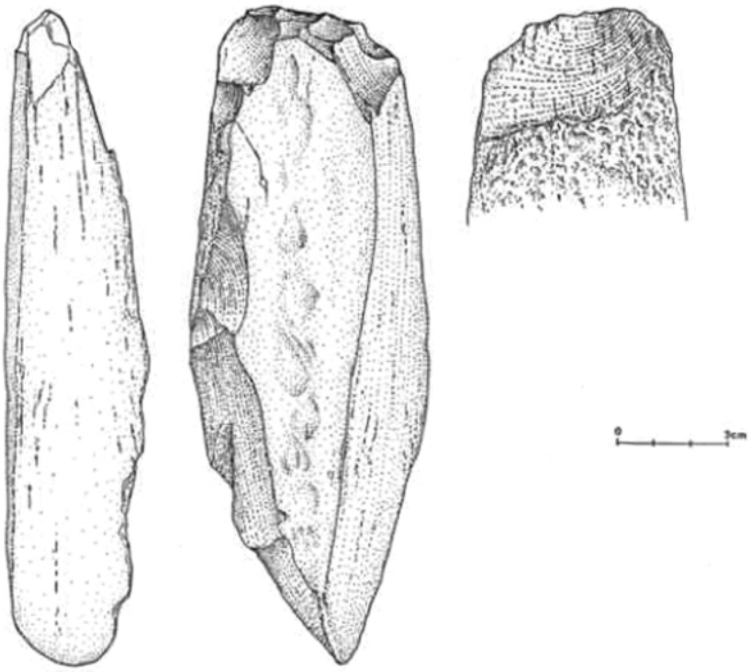

Fig.2 - Bone tool from Rebibbia - Casal de' Pazzi.

Données sur le gisement Pleistocène Moyen de La Polledrara di Cecannibio (Latium, Italie). In “*Les premiers habitants de L'Europe*”, Tautavel, 10-15 April 2000.

Anzidei, A.P. & Gioia, P. 1992. The lithic industry at Rebibbia-Casal de’ Pazzi. In *Papers of the Fourth Conference of Italian Archaeology. New Developments in Italian Archaeology, part I*: 155-179. London: Accordia Research Centre.

Arnoldus Huyzendveld, A. & Anzidei, A.P. 1993. Ricostruzione di un ambiente fluvio-lacustre nella regione vulcanica di Roma (La Polledrara di Cecanibbio). In *Atti della XXX Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria nel Lazio*: 151-165.

Anzidei, A.P., Arnoldus Huyzendveld, A., Caloi, L., Lemorini, C., Palombo, M.R. 1999. Two Middle Pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia-Casal de' Pazzi. In The Role of early Humans in the Accumulation of European Lower and Middle Palaeolithic Bone Assemblages. *Römisch-Germanisches Zentralmuseum Monograph* 42: 173-195.

Anzidei, A.P. & Ruffo, M. 1985. The Pleistocene deposit of Rebibbia-Casal de' Pazzi (Rome, Italy). In Papers in Italian Archaeology IV, Part I, The Human landscape. *BAR International Series* 243: 69-85.

Villa, P., Anzidei, A.P., Cerilli, E. 1999. Bones and Bone modifications at La Polledrara, a Middle Pleistocene site in Italy. In The Role of early Humans in the Accumulation of European Lower and Middle Palaeolithic Bone Assemblages. *Römisch-Germanisches Zentralmuseum, Monograph* 42: 197-206.

Mammoth bone technology at Tocuila in the Basin of Mexico

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SUMMARY: Tocuila is located along a paleoshore of Lake Texcoco within the Basin of Mexico that is part of the vast late Pleistocene Mexican Plains. Fractured bone represents human activity engaged in bone quarrying efforts to produce cores and flakes for future use. Fracturing is through high-speed impact using a percussion method of a focused and quick blow, causing combined tensions that result in a helical fracture in fresh long bones. A long bone segment has been shaped further into a bone core exhibiting prepared platforms. A series of overlapping flakes struck from this core have remnants of the prepared platforms. The great thickness of compact bone is appropriate to making these large cortical flakes. The bone technology seen at Tocuila is typical of a larger North American late Pleistocene tradition. This tradition represents an economic-technological use of mammoth resources rather than a subsistence one.

1. INTRODUCTION

The late Pleistocene (120,000 - 11,000 years BP) was a complex period of climatic shifts, changing faunal and floral communities, and impacted landscapes representing now extinct ecosystems. Changes in the biotas were initiated by global changes in climate that resulted in deglaciation in North America. Localized fluctuations on a regional and microgeographic basis also were involved (Nilsson 1983; Porter 1983). Therefore, the building blocks essential for understanding the Pleistocene and its biogeography must start with individual localities.

At the southern end of the North American grasslands, Tocuila (Morett *et al.* 1998a, b) is located in the Basin of Mexico within a volcanic area that was active during the late Pleistocene and is still active today. The locality is situated in a mudflow at the edge of Lake Texcoco, one of several shallow paleo-lakes within the main basin (Fig. 1). Remains of at least seven mammoths, ranging in age from young to adult, have been uncovered, along with a few bones from ungulates, rabbits and aquatic animals (Morett *et al.* 1998a, b; Corona-M. & Arroyo-Cabrales 1997). A number of radiocarbon dates (charcoal, seeds, and bone) from samples taken throughout the mud flow unit provide an average age of ca. 11,188 BP (Morett *et al.* 1998a; Arroyo-Cabrales *et al.* in press).

The main unit (ca. 1,7 m thick) containing the mammoth bones is stratified in a lahar (a mudflow caused by volcanic activity). Lahars form when heavy rains or melted snows wash loose volcanic debris down from higher to lower ground, usually flowing down a stream channel. Above this unit are deposits derived from smaller lahars. Volcanic ashes overlying lacustrine clays are stratified below the mammoth-bearing unit (Morett *et al.* 1998a). The lahar had flowed through and filled the channel of a late Pleistocene stream cut prior to the deposition of the unit containing the mammoth remains (Arroyo-Cabrales *et al.*, in press).

2. RESULTS AND DISCUSSION

The presence of humans is indicated by dynamic impact fracturing features on mammoth long bone segments and fracture debris. The assemblage is small but significant. A triangular-shaped femoral radial segment (TOC-1-281) exhibits a helical fracture at the apex, crushing and small flake removal along the opposite edge (i.e., the "base" of the triangle), and a series of large facets along the cortical surface below the crushed and small flake removal area (Fig. 2). This specimen is interpreted as a bone core with a prepared platform and scars from the removal of a number of large cortical flakes. Another specimen (TOC-1-534) has a number of facets on the cortical surface, an area of crushed bone and small flake removal at the top of the faceted area, and an undulating surface on the reverse side with a large diffuse bulge. This specimen is interpreted as a cortical bone flake with remnant platform preparation. The cortical flake conjoins with the central flake scar on the bone core.

The Tocuila cortical flakes are similar morphologically and share the same features as

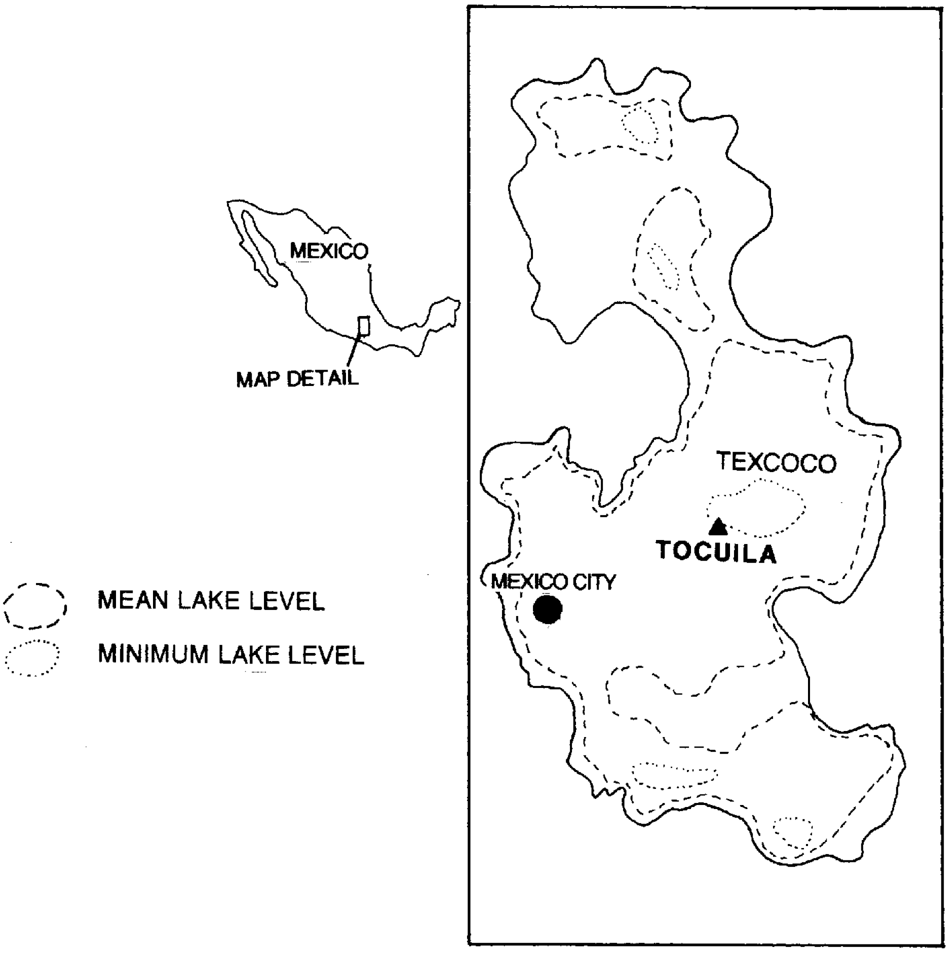

Fig.1 - Location of Tocuila in the Basin of Mexico.

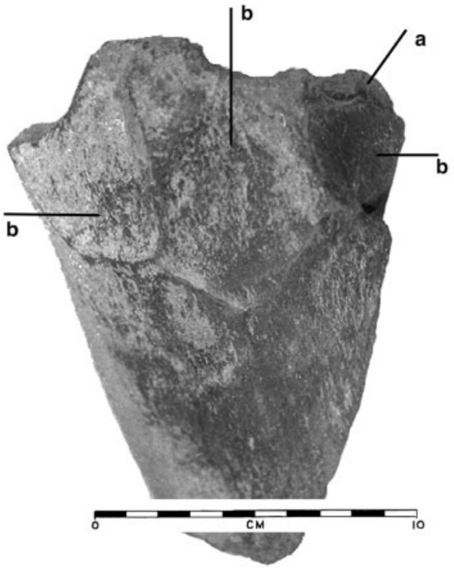

Fig.2 - Bone core from Tocuila, exhibiting edge crushing and small flaking from platform preparation (arrow a) and large flake scars (arrow b) from removal of large cortical flakes.

those from other North American grasslands mammoth sites (i.e., Lubbock Lake [Johnson in review], Lange-Ferguson [Hannus 1989, 1997], Duewall-Newberry [Steele and Carlson 1989], Owl Cave [Miller 1989]), and the experimentally-generated ones from Ginsberg (Stanford *et al.* 1981). The same relationship exists for the large cone flakes from Tocuila and other North American grasslands mammoth sites (i.e., Lubbock Lake [Johnson 1985], Sand Creek [Johnson *et al.* 1994], and Duewall-Newberry [Steele & Carlson 1989]). While human involvement with mammoth at Tocuila is limited, it is focused on bone breakage and interpreted as bone quarrying to produce cores for transport elsewhere.

Mammoth bone quarrying is a fracture-based bone technology, producing tool blanks and cores (Johnson 1985). Mammoth procurement for bone quarrying is a technological activity aimed at securing raw material shaped into transportable, useable forms (Johnson 1985; Hannus 1989; Miller 1989). Breakage is purposeful to cause segmentation and selected segments used in production endeavors. This bone quarrying is focused on the use of proboscidean bone as a resource for the production of cores and blanks in the same manner as stone is fractured from its quarry source to yield segments suitable to fashion cores and blanks. The great thickness of compact bone is appropriate to making large cortical flakes. Bone cores exhibit prepared platforms and flakes struck from those cores have remnants of their prepared platform.

3. CONCLUSION

Mammoth bone quarrying is a North American grasslands-wide technological activity with a great time depth (Johnson in review). It is dependent on the cortical thickness of mammoth limb bones and was dropped from the grasslands hunter-gatherer technological repertoire when mammoth become extinct.

The mode of accumulation of the remains of the Tocuila mammoths still is unclear, as information pertaining to the age, gender, and carcass condition of these animals is currently not available. Other than their deposition in the same unit, the relationship between the mammoth remains and the bone core and the flakes has not been defined. A mudflow is a catastrophic event. Due to the disarticulated nature of the remains, it appears that the mudflow did not kill the mammoths and other animals present in the fauna in the flow deposit. Whether the mammoth remains previously had been deposited in the channel (either as the result of attritional accumulation or a catastrophic event) and subsequently were covered by the mud flow or whether the mammoth remains were transported into the channel with the mud flow currently is being debated (Morett *et al.*, 1998a; Arroyo-Cabrales *et al.*, 1999, 2000; Siebe *et. al.* 1999).

4. Acknowledgements

This manuscript represents part of the ongoing Lubbock Lake Landmark regional research into late Quaternary paleoecology, taphonomy, and grassland hunter-gatherers on the Southern Plains. The Tocuila bone technology study is funded by the Museum of Texas Tech University (USA) and Instituto Nacional de AntropologÌa e Historia (México).

5. References

Arroyo-Cabrales, J., Gonzalez, S., Morett, L.A., Polaco, O.J., Sherwood, G.J., & Turner, A. in press. *The Late Pleistocene paleoenvironment of the Basin of México - evidence from the Tocuila mammoth site.* Deinsea, the Scientific Journal of the NatuurMuseum, Rotterdam.

Corona-M., E. & Arroyo-Cabrales, J. 1997. New record for the Flamingo (*Phoenicopterus* cf. *P. ruber* Linnaeus) from Pleistocene-Holocene transition sediments in Mexico. *Current Research in the Pleistocene* 14: 137-139.

Hannus, L.A. 1989. Flaked mammoth bone from the Lange/Ferguson site, White River badlands area, South Dakota. In R. Bonnichsen & M. Sorg (eds.), *Bone Modification*: 395-412. Orono: Center for the Study of the First Americans, University of Maine.

Hannus, L.A. 1997. Mammoth bone flake tools from the Lange/Furguson site, South Dakota. In L. A. Hannus, L. Rossum, & R. P Winham (eds.), *Proceedings of the 1993 bone modification conference*, Hot Springs, South Dakota. Augustana College, Sioux Falls, Archeology Laboratory, Occasional Publication 1: 220-235.

Johnson, E. 1985. Current developments in bone technology. *Advances in Archaeological Method and Theory* 8: 157-235. New York: Academic Press.

Johnson, E. in review. *Late Wisconsinan mammoth procurement in the North American grasslands.* Corvallis: Center for the Study of the First Americans, Oregon State University.

Johnson, E., Litwinionek, L., & Holliday, V.T. 1994. The Sand Creek mammoth site, Llano Estacado of Texas. *Current Research in the Pleistocene* 11: 70-72.

Miller, S.J. 1989. Characteristics of mammoth bone reduction at Owl Cave, the Wasden site, Idaho. In R. Bonnichsen & M. Sorg (eds.), *Bone Modification*: 381-393. Orono: Center for the Study of the First Americans, University of Maine.

Morett, L.A., Arroyo-Cabrales, J., & Polaco, O.J. 1998a. Tocuila, a remarkable mammoth site in the Basin of Mexico. *Current Research in the Pleistocene*, 15: 118-120.

Morett, L.A., Arroyo-Cabrales, J. & Polaco, O.J. 1998b. El sitio paleontològico de Tocuila. *Arqueologìa Mexicana* 5(30): 57.

Nilsson, T. 1983. *The Pleistocene. Geology and life in the Quaternary ice age*. Dordrecht: D. Reidel Publishing Co.

Porter, S. 1983. *Late-Quaternary environments of the United States*. Vol. 1. The Late Pleistocene. Minneapolis: University of Minnesota Press.

Siebe, C., Schaf, P., & Urrutia-Fucugauchi, J. 1999. Mammoth bones embedded in a Late Pleistocene lahar from Popocatèpetl Volcano, near Tocuila, central México. *Geological Society of America Bulletin* 111: 1550-1562.

Stanford, S., Bonnichsen, R. & Morlan, R.E. 1981. The Ginsberg experiment: modern and prehistoric evidence of a bone-flaking technology. *Science* 212: 438-440.

Steele, D.G. & Carlson, D.L. 1989. Excavation and taphonomy of mammoth remains from the Duewall-Newberry site, Brazos County, Texas. In R. Bonnichsen & M. Sorg (eds.), *Bone Modification*: 413-430. Orono: Center for the Study of the First Americans, University of Maine.

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On the significance of modified mammoth bones from eastern Beringia

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SUMMARY: Focusing on Late Pleistocene evidence obtained from the Old Crow Flats and the Bluefish Caves (northern Yukon Territory) and relying on finds made elsewhere, in both Eurasia and North America, this paper will examine, in a historical perspective, the nature, significance and implications of modified mammoth bone assemblages from eastern Beringia.

Nearly 30 years ago, it was announced that evidence had been discovered, in the Northern Yukon, in support of a pre-Late Glacial Maximum (Wisconsinan maximum) human occupation of easternmost Beringia (Irving & Harington 1973). The evidence in question consisted of an indubitable skin processing tool, called a "flesher" found together with numerous Late Pleistocene mammoth bone fragments that were described as having been intentionally modified. Recovered from one of the many fossiliferous (secondary) deposits located along the banks of the Old Crow River (Old Crow Flats) (Fig. 1) the specimens (the “flesher” itself and a few of the “modified” mammoth bones) yielded ^{14}C ages in the range of about 26,000 - 27,000 BP.

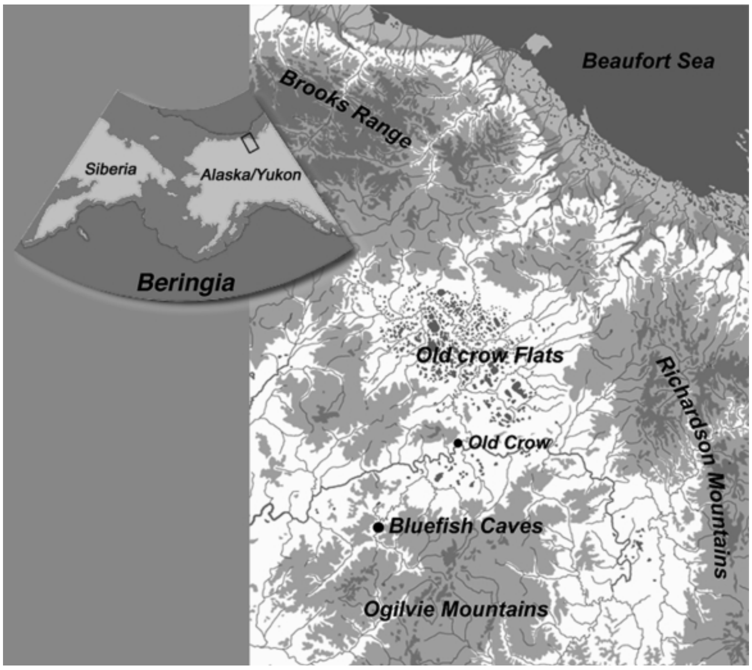

Fig.1 - Map showing the location of the Old Crow Flats and the Bluefish Caves, in the Upper Porcupine Basin (northern Yukon), as well as in the larger Beringian context.

Flying in the face of the established “Clovis First” model (Haynes 1987; Martin 1984), and referring, in part, to a technological category (flaked mammoth bones) that was essentially foreign to the interpretive repertoire of most American archaeologists involved in the initial “Peopling of the New World” question, the report was received with much skepticism and triggered an intense, interdisciplinary debate that was, over the next twenty years or so, to play itself out both in the field and in the literature.

Central to the controversy were issues concerning the nature and significance of the “modified” mammoth bones as well as questions pertaining to the validity of the age of the “flesher” and of its association with the modified mammoth remains. Relying on results obtained from both taphonomic and experimental studies, a number of workers (Bonnichsen 1979, Irving *et al.* 1989, Morlan 1980) concluded that many of the traits or attributes exhibited by some of the mammoth bone specimens in question were indeed culturally induced and, as such, telling of a human presence in the northern Yukon prior to the LGM (Fig. 2). Others, however, also making use of various taphonomic arguments, countered that much of the material under consideration could be better attributed to natural causes such as, for example, “animal trampling” (Agenbroad 1989; Haynes 1988), “animal gnawing” (Guthrie 1988), and “fluvial/river ice transport” (Thorson & Guthrie 1984).

By the late 1980's, the situation had reached a stalemate and this, despite mounting evidence, from elsewhere in North America (e.g., Hannus 1989; Miller 1989) as well as in Europe (Villa 1991) that certain types of modified proboscidean bones could indeed be viewed as representing a formal technological category worthy of analysis.

The debate came to a somewhat abrupt end in 1990 when it was reported (Morlan *et al.* 1990) that the “flesher” dated to no earlier than the beginning of the last millennium. Since the object was, in the eyes of many, the only “real” Old Crow artefact, its rejuvenation was received by most North American archaeologists as marking the end of a long controversy and resulted in the baby (the modified mammoth bones) being thrown away with the bathwater (the “flesher”).

For example, no attention was given to Morlan’s intriguing chronological/taphonomic argument (Morlan *et al.* 1990; Cinq-Mars & Morlan 1999) pointing to the fact that in the

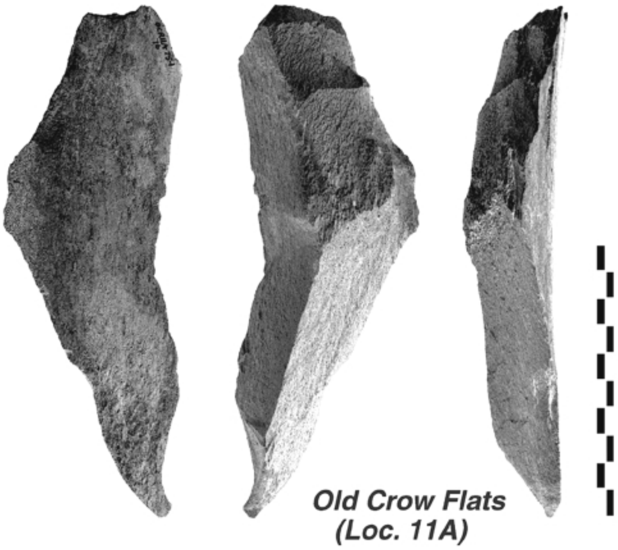

Fig. 2 - An example of a culturally modified mammoth bone object from the Old Crow Flats: it consists of a laminar splinter exhibiting bifacial trimming or reduction running perpendicular to the proximal end of the support.

Old Crow River deposits and derived fossil assemblages (which span much of the Pleistocene), mammoth bone specimens exhibiting modifications that can be interpreted as “intentional”, are not known to occur prior to about 40,000 years ago. This, in our view, marks the appearance, in eastern Beringia, of a new (taphonomic) agent that is best interpreted as indicative of human presence at a very early (Interpleniglacial) time.

Nor was there much consideration given to evidence obtained from the Bluefish Caves in the mid-1980’s. Located about 75 km southwest of the Old Crow Flats (Fig. 1), these three small shelters and their faunal-rich loess deposits have yielded a range of cultural indicators, including stone tools, and butchered or otherwise modified bones that suggest sporadic use of the caves between 15,000 and 10,000 years ago. Particularly interesting are a mammoth bone flake and its parent core which, taken together, can be shown to exhibit a complex sequence of reduction by percussion: first, of the core from which three flakes were detached and, subsequently, of one of the flakes which was reduced to about a third of its original size by bifacial trimming (Cinq-Mars 1990; Cinq-Mars & Morlan 1999 (Fig. 3).

These objects, which have been dated at about 23,500 years ago (Cinq-Mars & Morlan 1999) resemble in many ways - especially with regards to the reduction sequence - some of the

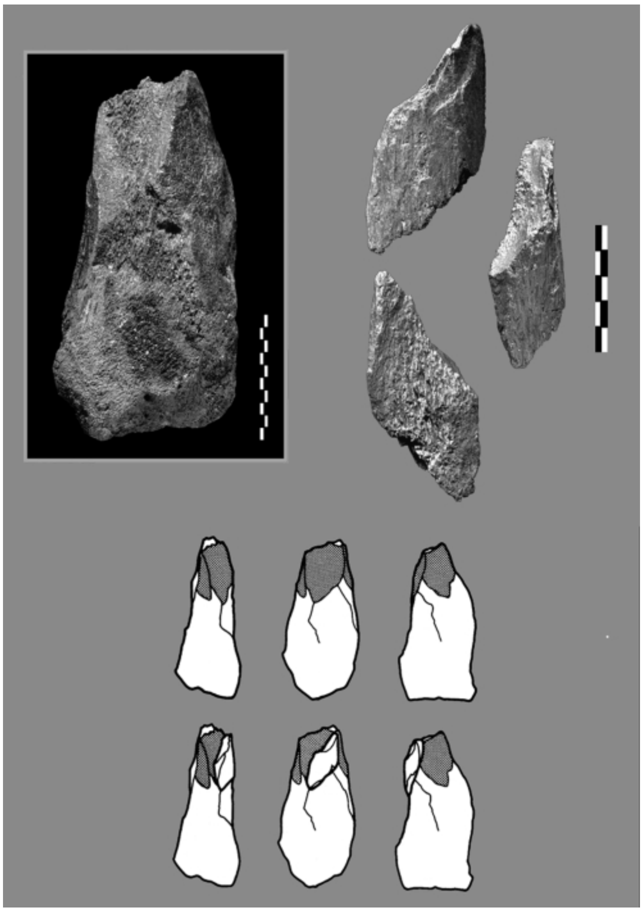

Fig.3 - Photographic montage showing the Bluefish Caves mammoth bone core (upper left) and the bifacially trimmed flake (upper right) mentioned in the text. The schematic drawings serve to illustrate the position of the three flake scars exhibited by the core (upper row) as well as the “refit” of the central flake on its parent core (lower row).

aforementioned Old Crow River specimens and, because of their upland, *in situ* context, can be used, parsimoniously, to reinforce the notion that the latter are more likely to have been produced by a cultural taphonomic agency than by natural causes. This becomes even more evident when the eastern Beringian material is compared (favourably) with that which has been recovered from other sites such as, for example, La Polledrara, in Italy (Anzidei *et al.* 1989) and the Lange/Ferguson and Owl Cave sites, in the United States (Hannus 1989; Miller 1989).

Despite their separation in space and in time, the assemblages recovered from these and a number of other localities can be used to demonstrate (1) that a technology making use of mammoth bone as raw material was indeed present in eastern Beringia during the Late Pleistocene and this, as early as 40,000 years ago, and (2), that the chronology of human dispersals into the New World is in need of re-examination.

REFERENCES

Agenbroad, L.D. 1989. Spiral Fractured Mammoth Bone from Nonhuman Taphonomic Processes at Hot Spring Mammoth Site. In R. Bonnichsen and M.A, Sorg, (eds.), *Bone Modification*: 139-147. Orono: Center for the Study of the First Americans, University of Maine.

Anzidei, A.P., Angelelli, A. Arnoldus-Huyzenveld, A., Caloi, L., Palombo, M.R. & Segre, A.G. 1989. Le gisement pléistocène de la Polledrara di Cecanibbio (Rome, Italie). *L'Anthropologie* 93 (3): 749-782.

Bonnichsen, R. 1979. *Pleistocene Bone Technology in the Beringian Refugium*. Archaeological Survey of Canada Paper No. 89, Mercury Series. Ottawa: National Museum of Man.

Cinq-Mars, J. 1990. La place des Grottes du Poisson-Bleu dans la préhistoire béringienne. *Revista de Arqueologia Americana* 1: 9-32.

Cinq-Mars, J. & Morlan, R.E. 1999. Bluefish Caves and Old Crow Basin: A New Rapport. In R. Bonnichsen and K.L. Turnmire (eds.), *Ice Age Peoples of North America. Environments, Origins, and Adaptations of the First Americans*: 200-212. Corvallis: Oregon State University Press - Center for the Study of the First Americans.

Guthrie, R.D. 1988. Bone Litter fron an Alaskan Pleistocene Carnivore. *Current Research in the Pleistocene* 5: 69-71.

Hannus, L.A. 1989. Flaked mammoth bone from the Lange/Ferguson site, White River Badlands area, South Dakota. In R Bonnichsen & M.A. Sorg (eds.), *Bone Modification*: 395-412. Orono: Center for the Study of the First Americans, University of Maine.

Haynes, C.V., Jr. 1987. Clovis Origin Update. *The Kiva* 52(2): 83-93.

Haynes, G. 1988. Longitudinal Studies of African Elephant Death and Bone Deposits. *Journal of Archaeological Science* 15: 131-157.

Irving, W.N. & Harington C.R. 1973. Upper Pleistocene radiocarbon-date artefacts from the northern Yukon. *Science* 179: 335-340.

Irving, W.N., Jopling, A.V. & Kritsch-Armstrong, I. 1989. Studies of Bone Technology and Taphonomy, Old Crow Basin, Yukon Territory. In R. Bonnichsen and M.A. Sorg (eds.), *Bone Modification*: 347-379. Orono: Center for the Study of the First Americans, University of Maine.

Martin, P.S. 1984. Prehistoric Overkill: The Global Model. In P.S. Martin and R.G. Klein (eds.), *Quaternary Extinctions: a Prehistoric Revolution*: 354-403. Tucson: University of Arizona Press.

Miller, S.J. 1989. Characteristics of Mammoth Bone Reduction at Owl Cave, the Wasden Site, Idaho. In R. Bonnichsen and M.A. Sorg (eds.), *Bone Modification*: 381-393. Orono: Center for the Study of the First Americans, University of Maine.

Morlan, R.E. 1980. Taphonomy and Archaeology in the Upper Pleistocene of the Northern Yukon Territory: A Glimpse of the Peopling of the New World.

Archaeological Survey of Canada Paper No. 94, Mercury Series. Ottawa: National Museum of Man.

Morlan, R.E., Nelson, D.E., Brown, T.A., Vogel, J.S. & Southon, J.R.. 1990. Accelerator Mass Spetrometry Dates on Bones from Old Crow Basin, Northern Yukon Territory. *Canadian Journal of Archaeology* 14: 75-92.

Thorson, R.M. & Guthrie, R.D. 1984. River Ice as a Taphonomic Agent: Alternative Hypothesis for Bone Artefacts. *Quaternary Research* 22: 172-188.

Villa, P. 1991. Middle Pleistocene Prehistory in Southwestern Europe: The State of our Knowledge and Ignorance. *Journal of Anthropological Research* 47: 193-217.

Ex Proboscideis - Proboscidean remains as raw material at four Palaeolithic sites, Hungary

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SUMMARY: The palaeontological data in this paper was provided by the archaeozoologist István Vörös. Evidence from four sites, Vértesszölös, Tata, Istállóskö cave and Esztergom-Gyurgyalag, characterised by the presence of objects made of Proboscidean remains are presented. Pleistocene faunas at both archaeological and palaeontological localities in the Carpathian Basin are dominated by the remains of the Elephantidae. The phylo- and ontogenesis of this taxon from the Pliocene-Pleistocene boundary till the middle of the Würm glaciation was established by István Vörös. Some 470 localities have yielded fossils belonging to this family. The bulk of these finds was recovered without any proper stratigraphical information from river banks, gravel quarries, open-air lignite mines and calcareous tuffs of varying age. In this context the Elephantidae function as "Leitfossil" due to the taxonomical significance of the evolution of their teeth.

1. INTRODUCTION

Archidiskodon meridionalis occurs from the boundary of the Pliocene-Pleistocene up till the end of the Lower Pleistocene. During the Middle Pleistocene *Mammuthus trogontherii* is the dominant species. Archaic forms of the mammoth appear as early as the Middle Pleistocene (at the Lower Palaeolithic site of Vértesszölös). The true woolly mammoth is recorded during the Upper Pleistocene until the inter-pleniglacial period (e.g. the Middle Palaeolithic site Tata at the beginning of this period and the Aurignacian site of Istállóskö at the end of this period).

By the Pleniglacial B period, mammoth is already absent from the faunas (Vörös 1998). Mammoth bones found at archaeological sites during this period probably derived from animals that were no longer part of the contemporary fauna (e.g. remains found at the site of Esztergom already belong to this "post-proboscidean" period).

2. THE LOWER PALAEOLITHIC SITE OF VÉRTESSZÖLÖS

The absolute chronological data for this site is extremely variable. Its relative chronological position based on terrace chronology, biostratigraphy (presence of archaic elements) and palynology (presence of relict floral elements) is clear.

The five occupation horizons are stratified in calcareous silts and travertine, in loess and sandy loess sediments containing rich smaller and larger mammal faunas, Ostracoda and molluscan faunas, and micro and macro plant fossils etc.). Human remains comprise the occipital bone of an adult man and fragments of the milk teeth of a child. The archaeological horizon comprising lithic flakes and tools, and animal bones interpreted as subsistence debris attains a depths of up to 60 cm in places.

Of special significance for the human occupation of the site are hearths formed by small fragments of animal bones.

Of particular interest at this site is a "handaxe" made from a medial fragment of a left tibia of an elephant. The tool is the retouched fragment of a split long bone. The tool was prepared using the same techniques used in lithic technology. Due to poor fossilisation, traces of use wear are not preserved on this find.

When first revealed during excavation the bones were rather greasy in appearance. Afterwards they became porous and fragile with no preservation of observable traces on their surfaces.

An albumin-residue analysis was undertaken on a fragment of this bone, in order to determine the exact Proboscidean species within the genus, as this could provide important chronological information for the fauna. Unfortunately this analysis did not produce any further data. However, based on biostratigraphical evidence of Elephantidae at non-archaeological Middle Pleistocene sites, I. Vörös attributed the species for this period to *Mammuthus trogontherii* (Vörös 1998).

More than 100 bone tools made of non-proboscidean raw materials were selected from the subsistence debris. With the exception of spirally fractured or cutmarked bones evidence for tool production is comparable to techniques utilised to produce stone tools.

The lithic inventories from the five cultural horizons display the same industry. Though the quantity and composition of lithic tools within the inventories varies from layer to layer, changes in parameters reflect an internal development within the lithic industries. Throughout the stratigraphical sequence an increase in the ratio of better quality silex raw material in comparison to quartzite, in the quantity of Middle Palaeolithic tools and in tool size can be observed.

3. THE MIDDLE PALAEOLITHIC PEBBLE INDUSTRY SITE OF TATA

Karstic phenomena are known from various places along the margin of the North-East Transdanubian Mesozoic mountain range in different periods of the Earth’s history. As a result of the last karstic phase, freshwater limestone has been produced from the beginning of the Pleistocene period up to the present day (Korpás 2000). Vértesszölös and Tata are both part of this karstic water system. Due to climatic and orographic factors karst processes were periodical and of varying intensity.

The archaeologically dated calcareous tuff at Tata formed on the second flood-free terrace. Humans at Tata specialised in hunting mammoth calves.

A medial fragment of a lamella from a lower molar of a mammoth was chosen for further modification. The tooth plate was completely polished. At the base of the irregular ridges of the polished surface, traces of ochre can be observed. The edges of the piece are profiled/polished. This object is unsuitable for utilisation. According to L. Vértes who initially published the object, this find could symbolise a spiritual connection between the human community and their principal game (Vértes 1965, 139).

The most unusual aspect of the Tata inventory is the average length of the tools: 31 mm. Larger tools have not been found so far. Thus, the discrepancy between the small size of the lithic tools and the large size of the main human prey has still to be clarified. During Lower, Middle and Upper Palaeolithic periods this contrasting pattern is observable at all pebble-using sites in Hungary.

4. ISTÁLLÓSKÖ CAVE SITE (BÜKK MOUNTAIN)

Two Aurignacian horizons are preserved in the sediments of this cave. Based on the horizontal and vertical distribution of the faunal material and an analysis of skeletal part representation of the fauna, during the first phase of occupation the cave was probably used during the summer to autumn as a hunting camp. This is supported by the composition of the archaeological inventory (many weapons / points, few tools).

During the younger phase of occupation the site was inhabited for a longer period of time. This interpretation is supported by the presence of a large hearth surrounded by blocks of stone, indicating a continuously inhabited home base site, where butchering and curation of animal hide also occurred (Vörös 1984).

Of significance are small and large fragments of a rod made of polished mammoth tusk. Fragments with intact surfaces are slightly bent, but the angle does not reflect the natural curvature of the tusk, showing that the tusk had been straightened. The lithic inventory is poor and atypical. Typical forms such as carinated scrapers, nosed end scrapers and busquet burins are absent in both Aurignacian levels of the cave. Within the older Aurignacian level split based bone-points function as a "Leitfossil". The younger Aurignacian level is characterised by the presence of Mladec bone points. Moreover, the faunas of both Aurignacian layers are dominated by *Rupicapra* (more than 50%); Cervidae (*Cervus, Rangifer, Alces*), *Ursus spelaeus*, and the steppic *Equus* and *Bison* are present along with carnivores of the deciduous forest such as *Canis* and *Vulpes* (Vörös 1984).

5. THE GRAVETTIAN OPEN-SITE OF ESZTERGOM-GYURGYALAG

The site is located on the first Würm terrace above the alluvial flood plain of the Danube.

Of particular interest is a fragment of a retouched, pierced tool (shovel?) made from the tibia of a mammoth. According to observations of I.Vörös, the opening was made by piercing four smaller holes of ca. 10 mm in diameter. During this period, the acquisition and occurrence of mammoth bones at archaeological sites raises a number of questions. Did the bones derive from animals which belonged to the contemporary fauna, were they obtained by hunting or by collecting the fossilised bones from river gravels?

The discrepancy between the faunistical data and the archaeological chronology cannot be explained by archaeological methods. ^{14}C data (16,160 BP) corresponds to the archaeological dating of the site. Mammoth bone appears to be an autochthonous element of the find assemblage. From a topographical and chronological point of view, the site belongs to a series of settlements located along the Danube-bend belonging to the short interstadial phase postdating the Würm 3 cold maximum.

REFERENCES

Dobosi, V.T. 1983. Data to the evaluation of the Middle Palaeolithic industry of Tata. *Folia Archaeologica* 34: 7-31.

Dobosi, V.T. 1990. Description of the Archaeological Material. In Kretzoi, M. and Dobosi, V.T. (eds.), *Vértesszölös, Man, Site and Culture*: 311-395. Budapest.

Korpás, L. 2000. Tata-Kálvária-domb. Paleokarszt jelenségek éskarsztfejlödési modell. In *Excursion-guide to HUNGEO 2000*: 27.

Vörös, I. 1984. Hunted mammals from the aurignacian Cave Bear hunter's site in the Istállóskö cave. *Folia Archaeologica* 35: 7-31.

Vörös, I. 1991. Large mammal remains from the Upper Palaeolithic site at Esztergom-Gyurgyalag. *Acta Arch Hung* 43: 261-263.

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The Krems-Wachtberg camp-site: mammoth carcass utilization along the Danube 27,000 years ago

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SUMMARY: During a rescue-excavation undertaken in 1930, 219 identifiable bones from at least eight mammoths, six wolves, five foxes, three wolverines, two reindeer, one red deer, two ibexes, and one musk ox were uncovered. Three AMS-dates from charcoal indicate a ^{14}C-age of 27,7-27,1 ka BP. Mammoth remains dominate the total bone count (141). The presence of four very young calves argues for a proliferating mammoth population. The skeletal representation pattern provides evidence for the transport of all butchering units, at least from the carcasses of the calves, from the death site. Cut marks are concentrated on rib surfaces. Multiple impact marks document the cleaving of massive long bones. Cortical bone fragments from limb bones and ribs were preferably used as raw material for tools.

The skeletal representation of the carnivores, and the cut mark and breakage pattern observed on their bones indicate skinning activities as well as consumption of the meat.

1. SITE LOCATION

The Krems-Wachtberg site is situated on an exposed south-easterly slope, at a height of 260 m a.s.l., within a cluster of Aurignacian and Gravettian sites. The topography is characterised by a hilly area with upland ridges with a base altitude of c. 500 m a.s.l. and peaks at c. 1000 m, and valley floors at c. 200-190 m a.s.l. In summer 1930 the chance discovery of bones within the loess sediments was followed by a short rescue excavation. The most striking feature within the small site of c.15 square meters were two ditches c. 30 cm in depths filled with ashy sediments (Einwögerer 2000).

The archaeological inventory comprises the oldest, and up till now the only two zoomorphic burnt clay figurines from Austria. The stone artefact assemblage yields c. 2300 finds including 70 tools and over 500 bladelets. Their morphology shows strong affinities to lithics from the Moravian sites of Dolní Vestonice and Pavlov, which are located approximately 100 km away.

Charcoal was determined as dwarf *Pinus* sp. and *Abies* sp (Cichocki 2000). AMS-dates (27,7–27,1 ka BP), the presence of clay figurines, and the stone tool analysis closely resembles assemblages assigned to the "Pavlovian" culture (for example Klíma 1965, Svoboda 1996).

2. MATERIAL

The bone sample comprises c. 340 elements and fragments. The archeological documentation did not include a complete inventory of all recoverable bones (Fladerer 2001, in press). The bone surfaces are corroded and destroyed by root etching, and only the deepest parts of cut marks made by humans are preserved (Fig. 4).

3. MAMMOTH BODY REPRESENTATION

Proboscidean remains dominate the total bone count (NISP 141, 53% of total NISP) as well as species representation. The skeletal representation shows that elements of the heads, including isolated teeth, represent up to 25% of the carcass remains. An analysis of cranial fragments shows that the age structure predominantly comprises four calves and subadults

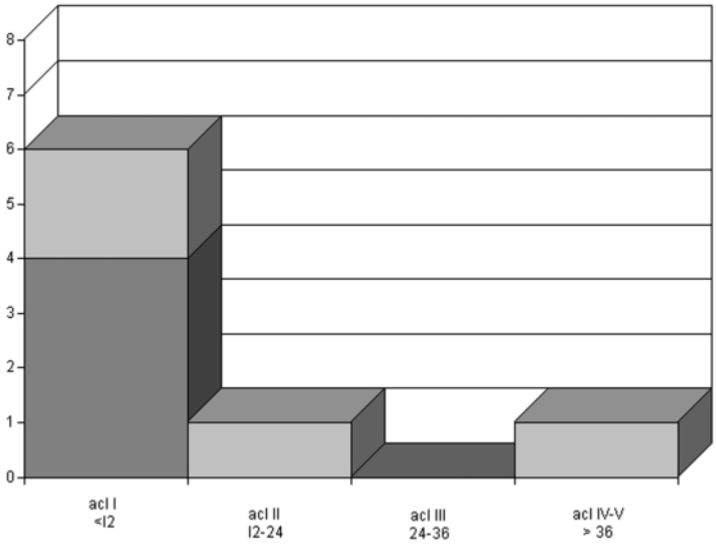

Fig.1 - Age structure of eight mammoths from the Krems Wachtberg, 1930 excavation. Dark shaded area in age class I indicates proportion of nursing calves, younger than two years. Individual count vertically, age classes and year intervals horizontally (after Haynes 1987) (from Fladerer 2001).

(Figs. 1-2). In addition two smaller individuals (older juveniles or young adults (females?)) can be recognized from postcranial material. The diaphysis of a femur of a small subadult individual, and part of an articulated anterior left foot represent individuals 5 and 6. At least one animal older than individual 6 and younger than the adult male is represented by the metapodials. This subadult (individual 7) may have died between 16-26 years. A right tusk (187 cm in length) represents a bull mammoth. Amongst the postcranial material adult individuals could be identified from several rib fragments, and several cortical limb bone fragments. These bones could belong to the putative bull (Fig. 3).

The presence of parts of the head, such as skull and jaw fragments indicate dismemberment of the head during an advanced stage of butchering. In the case of at least one of the calves and the subadult individual 6, heads have been transported to the camp. Foot bones of calves and adult individuals occur in the living-floor assemblage and are evidence of the removal of the feet at the death site (Fig. 3). Carpals, tarsals and phalanges are common elements at regional Upper Paleolithic residential sites (Fladerer 2001).

4. Mammoth Bone Modification and Bone Use

Impact notches on several long bones represent the most striking form of modification at the Krems-Wachtberg site (Fig. 3). Multiple notches can be observed on the 43 cm long proximolateral fragment of a femur. At least eight impacts are aligned on the caudal face of one of the longitudinal fracture edges. Approximately 15 cortical bone fragments attest to the fracturation of long bones and ribs.

The modification of the lower mandible of juvenile mammoth 4 with its missing teeth and mandibular arches is worthy of particular notice. The left alveolus of the third milk molar and the first permanent molar are filled with a grey ashy material. The base of the concreted ashy filling in the cavity has been exposed during excavation or in the course of the following 60 years due to damage of the mandibular bone (Einwögerer 2000). The morphology of the convex base is regular and does not dispay the irregular surface that would usually be observed on the negative of a base of the filling of an alveola. A modification of the jaw by palaeolithic humans is also strong-

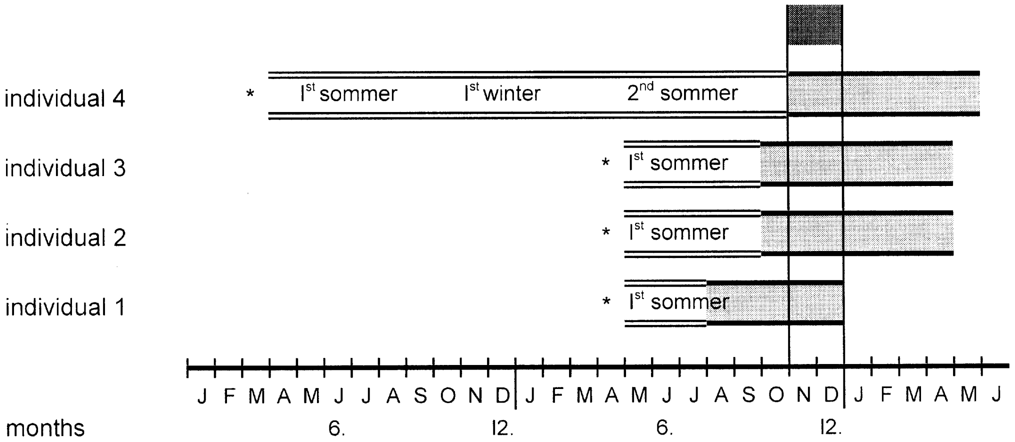

Fig.2 - Individual ages at death of four nursing mammoth calves as suggested by dental development, attrition, and replacement according to Laws (1966; see also Saunders 1992) and G. Craig (in Haynes 1991). Asterisk: hypothetical date of birth. Light shaded area: possible span of individual tooth-age. Short dark bar at the top indicates a possible common death season for all four individuals in the early winter months (November/December). From Fladerer (2001), modified.

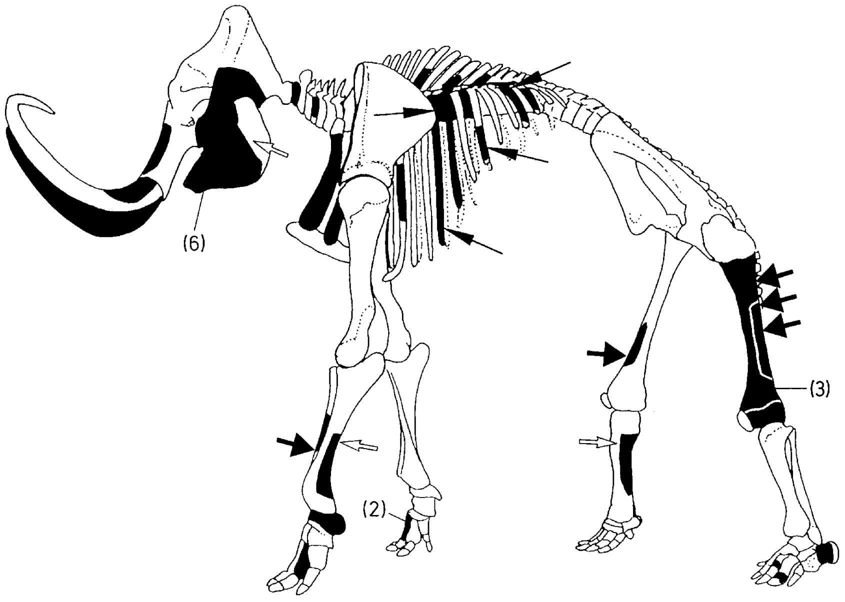

Fig.3 - Body-part representation of mammoths (shaded). Numbers in parentheses indicate the minimum number of individuals counted on each element. Short arrows in bold face: impact marks. Long narrow arrows: cut marks. White arrows: breakage probably resulting from a heavy blow. Outline after Mol & Essen (1987). From Fladerer (2001).

ly suggested due to the lingual edges of the first molar. Both sides show symmetrically destroyed (and later corroded) lingual walls, and the molars were apparently intentionally removed. Some tusk fragments show modifications which are also interpreted as produced by humans (Fladerer 2001).

Cut marks are preserved on six out of a total of 110 specimens, and occur on ribs and cortical bone fragments (Fig. 4; Fladerer 2001).

Bones were utilised and modified as tools:

(1) A compact bone fragment (134 mm long x 12,7 mm thick) was heavily reduced on the medular face by scar-like modifications. It was probably used as a core.

(2) The distal fragment of an anterior rib with spongiosa exposed (maximum width of 57 mm) is comparable to spoon-like tools from Dolní Vestonice II (Klíma 1995). Both cranial and lateral edges, and the terminal-ventral edge are polished by use.

(3) A fragment of a caudal rib (165 mm in length) displays reduced cranial and caudal edges along the dorsal part of its preserved length, and a distinct terminal-ventral smoothing. This find compares with flesher-like or polisher-like implements shown, for example, by Klíma (1995).

(4) A broken juvenile rib (65 mm in thickness) has been smoothed terminally comparable to find no 3.

(5) MK 1047 is a multiple retouched spindle (bobbin)-like tool made from a cortical fragment of a long bone (Fig. 5). The flat fragment (18x5x1,5 cm) is terminated proximally and distally by transverse fracture edges. One side is dominated by a large longitudinal spiral fracture lending a blade like appearance to the find. The opposite side is primarily modified by three impact notches, two of which were directed to the outer side of the bone producing a bifacial modification. At least three additional smaller notches have produced a scalloped edge. Polish within the notches also suggests utilisation of the tool as a flat spindle (bobbin). A few additional fragments, mainly from ribs and thick cortical long-bones, with flake scars, support evidence of the importance of mammoth remains as a main source of raw material for the Pavlovian people.

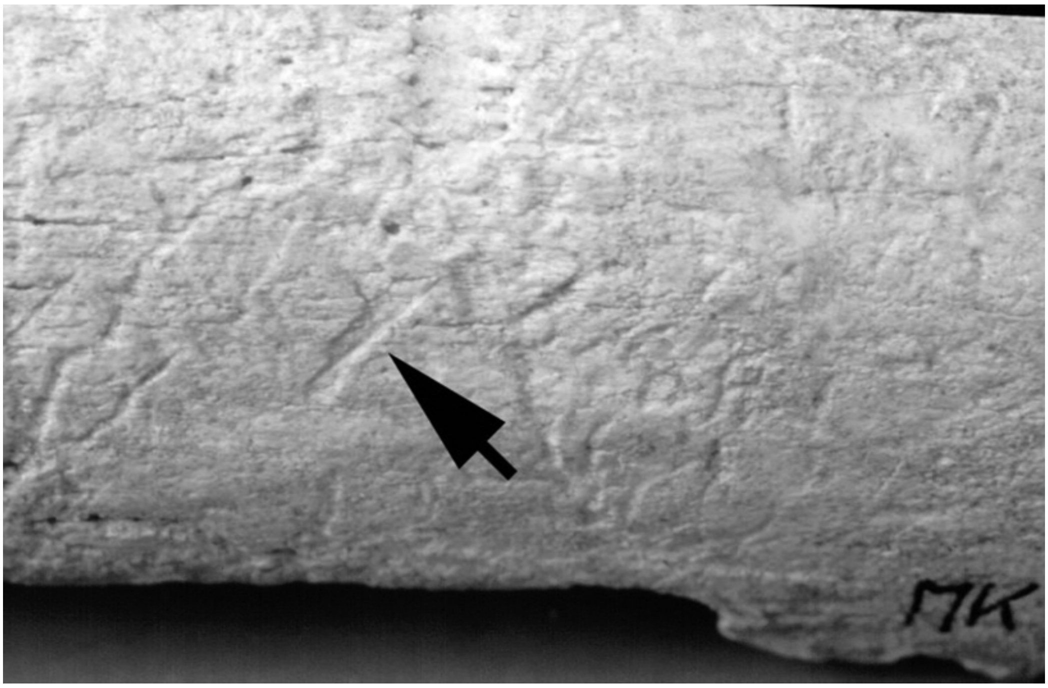

Fig.4 - Cut-mark (lenght = 7 mm) on the external side of a mammoth rib (MK 1063).

Fig.5 - Krems-Wachtberg, bobbin-like bifacially worked cortical bone tool made from mammoth bone (MK 1047), left: external view, middle: centre, right: internal view.

5. MEDIUM-SIZED HERBIVORES AND CARNIVORES

Rangifer tarandus, Capra ibex, and *Cervus elaphus* which are the most important prey species for the regional middle Upper Palaeolithic (e.g. Musil 1959; Fladerer 1996; West 1997), are represented at Krems-Wachtberg by only a few limb fragments and pieces of antler. The total of 14 carnivore individuals (*Canis lupus*: 6, *Vulpes vulpes*: 4, *Alopex lagopus*: 1, *Gulo gulo*: 3) in the sample represent over 50 % of the total MNI. Articulated bones provide evidence of the deposition of carcass parts enclosed in soft tissues and/or a rapid burial of the finds. This evidence together with impact notches documenting the opening of the medullar cavity along with cut marks produced during filleting can be observed on bones of both herbivores and carnivores. The skeletal representation and modification patterns (in terms of cut marks and impact notches) of the bones of the four species of carnivore do not significantly differ from one another (Fig. 6).

They document stages of carcass processing indicating additional utilisation of the carcasses, probably as a source of food. Some ritual meaning in the abundance of carnivores at Central European Late Paleolithic sites is postulated by

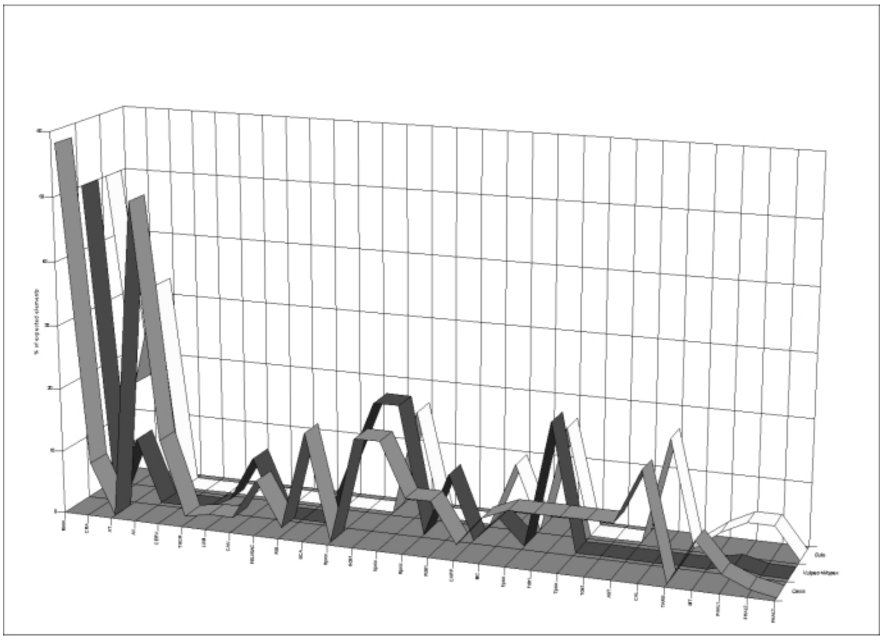

Fig.6 - Percentage of the observed elements of wolves (*Canis lupus*) and foxes (*Vulpes vulpes, Alopex lagopus*) vs. the expected number after the minimum number of individuals (Fladerer 2001).

Soffer (1993). However, since the documentation of the excavated living floor at the Krems-Wachtberg site is very poor, primary location and individual orientation of the bones necessary to test such a hypothesis cannot be reconstructed. Due to the state of preservation and the presence of articulated bones, a rapid natural embedding, or burial by humans, is indicated for the bulk of the faunal remains. Evidence for preserving, collecting and occasionally the selection of bones from anatomically similar positions, along with the burial of carnivore carcass parts, has also been recorded at other Pavlovian residential sites with zoomorphic figurines (e.g. Dolní Vestonice, Absolon 1938).

6. CONCLUSIONS

The common occurrence of anatomical units of the carcasses, evidence of significant carnivore activities, and no obvious differences in the weathering stages within the assemblage, suggests that an attritional mammoth death structure from a time-averaged background is unlikely. Evidently, the sample contains selected parts of a local mammoth herd, which is biased towards juvenile individuals. Juvenile mammoths argue against long-term stress within the Middle Danube mammoth population at 27 ka BP since healthy modern elephant populations contain at least c. 30% juvenile and subadult animals (Haynes 1992). In a generalized analogy, the Krems-Wachtberg sample represents at least a group of four nursing females and their calves, which may indicate a herd of up to 20-40 mammoths. The skeletal representation pattern indicate transportation of head, back, and foot parts, as well as long bones and ribs from the death site. Cut marks are concentrated on rib surfaces. Multiple impact notches document the cleaving of massive long bones, sometimes used for bone tool production (Fig. 5).

At least one male may have been part of the mixed herd, or this animal may derive from a separate foraging event. Communal targeting of a complete family group, as suggested by Saunders (1992), seems plausible. The landscape around Krems provided a variety of settings where animals could be ambushed. Several animals may have been ambushed during seasonal migration.

Similar hunting methods were probably used at sites in Southern Moravia (e.g. Klíma 1995, Svoboda 1996), which were partly occupied in the summer. This is indicated by the remains of neonate mammoth calves at several sites in the Middle Danube region. The site of Krems-Wachtberg, was probably occupied during the first months of the winter as deduced from mammoth calf demography (Fig. 2). This interpretation of the season is in accordance with the great volume of ashy deposits within the excavation field.

Furthermore the exploitation of animal fur, and evidence for the extraction of marrow is economically important between autumn and mid-winter when the animals are in a prime condition. In terms of complex subsistence settlement practices, it is suggested that a pattern of communal hunting of mammoth in particular functioned from seasonally aggregating camps during the Upper Palaeolithic period in the Middle Danube region.

7. REFERENCES

Absolon, K. 1938. Die Erforschung der diluvialen Mammutjäger-Station von Unter-Wisternitz an den Pollauer Bergen in Mähren. Arbeitsbericht über das erste Jahr 1924 - Studien aus dem Gebiete der allgemeinen Karstforschung, wissenschaftlichen Höhlenkunde, Eiszeitforschungen und Nachbargebieten, C, *Palaeoethnologie*, 5: 1-52.

Cichocki, O. 2000. Xylotomische Untersuchungen an paläolithischen Holzkohlefunden. In Th. Einwögerer: 197-201.

Einwögerer, Th. 2000. *Die jungpaläolithische Station auf dem Wachtberg in Krems*, NÖ. *Mitt. Prähist. Komm. Österr. Akad. Wiss., Phil.-Histor. Kl.* 34: 1–204, Wien.

Fladerer, F.A. 2001. Die Faunareste von Krems-Wachtberg, Ausgrabung 1930. Jagdwild und Tierkörpernutzung an der Donau vor 27.000 Jahren. *Mitt. Prähist. Komm., Österr. Akad. Wiss., Phil.-Histor Kl.* 39: 1-97. Wien (abstract, figure and table texts in English).

Fladerer, F.A. (in press). A calf-dominated mammoth age profile from the 27 ka BP stadial Krems-Wachtberg site in the middle Danube valley. *Deinsea*.

Haynes, G. 1987. Proboscidean die-offs and die-outs: age profiles in fossil collections. *J. Archeol. Sc.* 14(6): 659-668.

Haynes, G. 1991. *Mammoths, mastodonts, and elephants*. Cambridge: Univ. Press.

Haynes, G. 1992. The Waco mammoths: possible clues to herd size, demography, and reproductive health. In J.W. Fox, C.B. Smith & K.T. Wilkins (eds.), *Proboscidean and Paleoindian Interactions*: 111-122. Waco: Baylor Univ. Pres.

Klíma, B. 1995. Dolní Vestonice II. *Études et recherches archéologiques de l'Université de Liège* 73: 1-188.

Laws, R.M. 1966. Age criteria for the African elephant *Loxodonta africana*. *East African Wildlife J.* 4: 1-37.

Mol, D. & van Essen, H. 1992. *De mammoet. Sporen uit de IJstijd. 's-Gravenhage*: BZZToH.

Musil, R. 1959. Osteologický materiál paleolitického sídlisté v Pavlové. Cást II - *Anthropozoikum* 8: 83-106.

Saunders, J.J. 1992. Blackwater Draws: mammoths and mammoth hunters in the terminal Pleistocene. In J.W. Fox, C.B. Smith & K.T. Wilkins (eds.), *Proboscidean and Paleoindian Interactions*: 123-147. Waco: Baylor Univ. Press.

Soffer, O. 1993. Upper Paleolithic adaptations in Central and Eastern Europe and man-mammoth interactions. In O. Soffer & N.D. Praslov (eds.), *From Kostenki to Clovis: Upper Paleolithic - Paleo-Indian Adaptations*: 31-49. New York.

Svoboda, J. 1996. The Pavlovian: typology and behaviour. *J. Svoboda, P. Škrdla & E. W. Oches (Paleolithic in the Middle Danube region)*: 283-298. Brno.

West, D. 1997. Hunting strategies in Central Europe during the Last Glacial Maximum. *British Archaeological Reports, Int. ser.* 672: 1–153.

Mammoth bone quarrying on the late Wisconsinan North American grasslands

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SUMMARY: During the late Wisconsinan, the vast North American grasslands stretched from the Basin of Mexico through the Great Plains and eastward. Mammoth are one of the available resources within this expansive setting. Mammoth bone as a production resource involves high-speed impact using a percussion method of a focused and quick blow that causes combined tensions that result in a helical fracture in fresh long bones. Breakage is purposeful to cause segmentation and selected segments used in production endeavors. This bone quarrying is focused on the use of proboscidean bone as a resource for the production of cores and blanks in the same manner as stone is fractured from its quarry source to yield segments suitable to fashion cores and blanks. Procurement for technological pursuits throughout the time period is through hunting and scavenging found fresh carcasses.

1. INTRODUCTION

During the late Pleistocene, the North American grasslands stretched from the Basin of Mexico through the Great Plains and eastward (Fig. 1). The extent of these grasslands and the resources they contained are significant aspects in examining the late Pleistocene peopling of the landscape and evidence for early occupations. Research addressed here is centered on mammoth remains from the southern grasslands. The time span is a ca. 7000 year period from ca. 18,000 to 11,000 BP, encompassing seven localities spanning the Southern Plains and Mexican Plains.

2. MAMMOTH LOCALITIES

While a number of mammoth localities occur throughout the Great Plains during the Wisconsinan (Graham & Lundelius, 1994), those from the late Wisconsinan associated with early peoples are limited. That limitation is further reduced by restricting the localities to those site collections meeting the research criteria. Seven mammoth localites have been selected based on the following criteria: 1) presence of cultural modification to the mammoth bone in the form of bone technology; 2) available appropriate radiocarbon ages; and 3) confirmation of cultural modification to bone through review of the collection by the author.

Fracture-based bone technology is being investigated. Mammoth bone as a production resource is a significant aspect of carcass utilization. High-speed impact using a percussion method of a focused and quick blow causes combined tensions that result in a helical fracture in fresh long bones. Fresh bone breakage by people has an impact point that is a circular depressed area (an inverted cone) caused by localized compression failure. Ring cracks, crushed bones, and cone flakes (technological flakes coming from the interior of the impact zone) result from impact. Fracture fronts expand out from the impact zone in a radial patten until they merge, intersect, are deflected, or energy is dissipated. Radial diaphyseal (shaft) segments are produced through fracture and intersecting fracture fronts (Johnson, 1985, 1991). Breakage is purposeful to cause segmentation and selected segments used in production endeavors. This bone quarrying is focused on the use of proboscidean bone as a

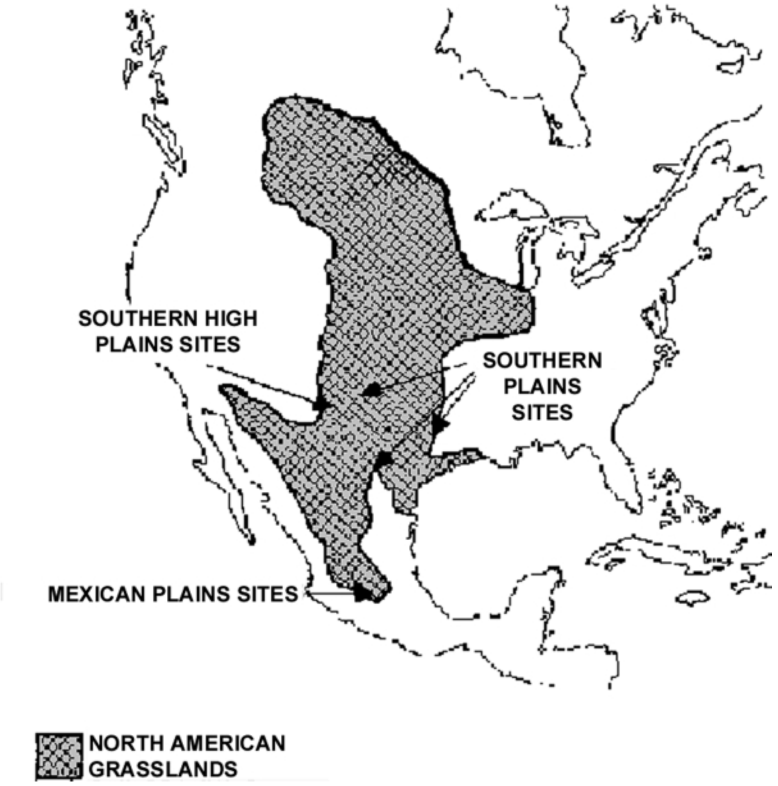

Fig.1 - North American grasslands with general location of mammoth bone quarry sites on the Southern Plains and Mexican Plains.

resource for the production of cores and blanks in the same manner as stone is fractured from its quarry source to yield segments suitable to fashion cores and blanks. The great thickness of compact bone is appropriate to making large cortical flakes. Bone cores exhibit prepared platforms and flakes struck from those cores have remnants of their prepared platform.

2.1 Southern Plains

Six localities on the Southern Plains represent a more central part of the vast grasslands (Fig. 1). These localities are positioned within a non-glacial landscape that was formed through depositional and erosional processes from aggrading and downcutting and dissolution and aeolian activities. They are located along streams or at the edge of paleo-lake basins.

Lubbock Lake Landmark is located in an entrenched meander of Yellowhouse Draw at a place where springs have flowed since at least the Late Pleistocene (Johnson 1987). The particular late Pleistocene occupation of interest is on top of a gravel bar and is dated ca. 11,100 yr BP (wood) (Johnson 1987). Helically-fractured mammoth long bones, radial diaphyseal segments, debris with intersecting fracture fronts, and cone flakes indicate bone quarrying occurring along a point bar. A cortical bone flake with a remnant platform points to core production and use as one of the purposes of bone quarrying (Johnson 1985).

The Sand Creek Mammoth (Johnson *et al.* 1994) is in lacustrine sediments from a paleolake basin, dated ca. 13,450 yr BP (organic sediments). Human influence is in terms of dynamic impact fracturing features and debris. A number of cone flakes from the impact zone and debris with intersecting fracture fronts and helical surfaces indicate breakage of fresh long bones by people. The cone flakes are consistent with those found at Lubbock Lake. A number of smaller cone flakes from small ring cracks were found in place overlapping each other. Bone quarrying was occurring with the Sand Creek mammoth carcass, the specific purpose of which is unknown.

Blackwater Draw Locality No. 1 (the Clovis site; Hester 1972) is in a paleo-lake basin that drains into Blackwater Draw. At one of the mammoth localities within the site (dated ca. 11000 yr BP), a humerus and diaphyseal segment were mapped but now are missing. Their representation and adjacent positions suggest a helically-fractured humerus (similar breakage pattern to the humerus at Lubbock Lake) and its associated large humeral diaphyseal segment (Johnson & Holliday 1997). If correct, then bone quarrying was occurring with this carcass. The large diaphyseal segment would appear similar to one at Lubbock Lake that has been interpreted as a blank from which mammoth bone foreshafts and wrenches would have been made (Johnson 1985: 203). Mammoth bone foreshafts were recovered in another part of the paleobasin (Hester 1972: 117).

Cooperton (Anderson 1974) is located along the edge of a small tributary creek. Radiocarbon dates range from 17,575 to 20,400 yr BP (bone and tooth) with large sigmas, indicating a late glacial maximum age. The right scapula and both humeri were helically-fractured. The humeri were broken in the same manner as that at Lubbock Lake (mid-diaphysis above the supracondyloid crest) and some of the diaphyseal segments could be refitted. Although the specific purpose is unknown, bone quarrying was occurring with this carcass (Anderson 1975: 171; Johnson 1991).

Duewall-Newberry (Steele & Carlson 1989) is located along the Brazos River. Both humeri and the right femur were helically-fractured, exhibiting excellent dynamic loading points, cone flakes, and flake scars (Steele & Carlson 1989: 424-225, Figs. 15 and 16). The elements were broken in the same manner as those at Lubbock Lake. Large diaphyseal segments and cortical flakes indicated bone quarry operations for the production of both blanks and cores (Johnson 1985, 1991).

Bonfire Shelter (Bement 1986) is at the southern end of the Southern Plains, in a rockshelter along Mile Canyon, a tributary of the Rio Grande. Limited mammoth remains were recovered around small limestone blocks in Stratum H-1 (dated ca. 12,400 yr BP [diffuse charcoal]) and Stratum E (bracketed between dates of ca. 12,400 - 10,200 yr BP) (Bement 1986). A tibial diaphyseal segment from Stratum H-1 and a long-bone diaphyseal segment from Stratum 1E are helically-fractured. These elements indicate limited bone quarrying occurring, probably for the production of diaphyseal blanks (Johnson 1985, 1991).

2.2 Mexican Plains

The grassland corridor from northern México to the Basin of México is termed the Mexican Plains. At the southern end of the grasslands, Tocuila is located in the Basin of México (Fig. 1). The locality is in a mud flow at what was an edge of Lake Texcoco. Remains of at least seven mammoth are in a deposit with several radiocarbon dates (charcoal, seeds, and bone) that average ca. 11,188 yr BP (Morett *et al.* 1998; Arroyo-Cabrales *et al.*, in press).

A triangular-shaped femoral radial segment exhibits a helical fracture at the apex, crushing and small flake removal along the opposite edge, and a series of large facets along the cortical surface. Another specimen has a number of facets on the cortical surface, an area of crushed bone and small flake removal at the top of the faceted area, and an undulating surface on the reverse side with a large diffuse bulge. These specimens are interpreted as a bone core and a cortical bone flake. The cortical flake conjoins with the central flake scar on the bone core. The Tocuila and Lubbock Lake cortical flakes are morphologically similar and share the same features. The same relationship exists for the large cone flakes from Tocuila, Lubbock Lake, and Sand Creek. While human involvement with mammoth at Tocuila is limited, it is focused on bone breakage and interpreted as bone quarrying to produce cores for transport elsewhere (Johnson *et al.* 2001).

3. DISCUSSION

The localities span the ca. 7000 to 8000 year time period from the last glacial maximum to terminal Pleistocene. This time range assumes that available radiocarbon ages for the localities are valid, but those from Cooperton (Anderson 1974) are most suspect. However, comparable dates are available from similar sites in the Central Plains (Holen 1994, 1996, 1999; May & Holen 1993) that underscore the plausibility of people and mammoth procurement at this early time on the North American grasslands.

Bone quarrying is a type of specialized site. The earliest evidence of mammoth procurement appears to be for the purpose of bone quarrying. Evidence of meat acqusition activities at Cooperton is lacking. Activity at La Sena in the Northern Plains at the same time appears oriented only towards bone quarrying (Holen 1994, 1999; May & Holen 1993). Mammoth procurement for bone quarrying is not a subsistence activity but rather a technological one aimed at securing raw material shaped into transportable, useable form. The activity is akin to that at a lithic outcrop and for a similar purpose. This type of mammoth procurement appears in two modes, either as a concordant activity occurring in concert with the butchering of a mammoth or as an independent activity. Bone quarrying is a specialized activity that requires fresh mammoth bone. Mammoth bone quarrying is a North American grasslands-wide technological activity with a great time depth. It is dependent on the cortical thickness of mammoth limb bones and drops from the grasslands hunter-gatherer technological repertoire as mammoth become extinct.

4. CONCLUSION

For Late Wisconsinan grasslands peoples, mammoth procurement apparently has two main purposes that could be accomplished in two ways. A mammoth carcass represented meat-related subsistence and raw material economy. Based on the database and available literature, it would appear mammoth did not become a food item until ca. 13,000 years ago; prior to that, mammoth limb bones are quarried for raw material, without direct evidence on the bones for butchery in meat acquisition.

People are on the North American grasslands prior to the terminal Pleistocene and had developed strategies to obtain some of the resources represented by a mammoth carcass. Mammoth procurement for whatever purpose using any strategy, however, comes to an end as mammoth become extinct. That part of the late Wisconsinan repertoire and lifestyle is abandoned and a cultural response of transformation or replacement of strategies ensued.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Anderson, A.D. 1975. The Cooperton mammoth: an early man bone quarry. *Great Plains Journal* 14(2): 130-173.

Arroyo-Cabrales, J., Gonzalez, S., Morett, L.A., Polaco, O.J., Sherwood, G.J., & Turner, A. in press. The Late Pleistocene paleoenvironment of the Basin of México - evidence from the Tocuila mammoth site. *Deinsea*.

Bement, L.C. 1986. Excavation of the Late Pleistocene deposits of Bonfire Shelter, Val Verde County, Texas. University of Texas at Austin, Texas Archeological Survey, *Archeology Series Paper* 1: 1-69.

Graham, R.W. & Lundelius Jr., E.L. 1994. Faunmap: a database documenting Late Quaternary distributions of mammal species in the United States. Illinois State Museum. *Scientific Papers* 25(2): 1-690.

Hester, J.J. 1972. *Blackwater Locality No. 1. A*

Stratified, Early Man Site in Eastern New Mexico. Dallas: Fort Burgwin Research Center, Southern Methodist University.

Holen, S.R. 1994. *Sites without lithics: mammoth bone processing sites in the Late Wisconsinan loess of Nebraska*. Paper presented at the 27th annual meeting of the Canadian Archaeological Association, Edmonton.

Holen, S.R. 1996. The Lovewell mammoth: a Late Wisconsinan site in North-Central Kansas. *Current Research in the Pleistocene* 13: 69-70.

Holen, S.R. 1999. *Late Pleistocene bone technology in the North American Mid-Continent.* Paper presented at the Clovis and Beyond Conference, Santa Fe.

Johnson, E. 1985. Current developments in bone technology. *Advances in Archaeological Method and Theory* 8: 157-235. New York: Academic Press.

Johnson, E. 1987. *Lubbock Lake. Late Quaternary studies on the Southern High Plains*. College Station: Texas A&M University Press.

Johnson, E. 1991. Late Pleistocene cultural occupation on the Southern Plains. In: R. Bonnichsen & K.L. Turnmire (eds.), *Clovis: Origins and Adaptations*: 215-236. Corvallis: Center for the Study of the First Americans, Oregon State University.

Johnson, E. & Holliday, V.T. 1997. Analysis of Paleoindian bonebeds at the Clovis site: new data from old excavations. *Plains Anthropologist* 42(161): 329-352.

Johnson, E., Litwinionek, L., & Holliday, V.T. 1994. The Sand Creek mammoth site, Llano Estacado of Texas. *Current Research in the Pleistocene* 11: 70-72.

Johnson, E., Morrett A., L. & Arroyo-Cabrales, J. 2001. Late Pleistocene bone technology at Tocuila, Basin of México. *Current Research in the Pleistocene* 18.

May, D.W. & Holen, S.R. 1993. Radiocarbon ages of soils and charcoal in Late Wisconsinan loess, south-central Nebraska. *Quaternary Research* 39: 55-58.

Morett, L.A., Arroyo-Cabrales, J., & Polaco, O.J. 1998a. Tocuila, a remarkable mammoth site in the Basin of Mexico. *Current Research in the Pleistocene* 15: 118-120.

Steele, D.G. & Carlson, D.L. 1989. Excavation and taphonomy of mammoth remains from the Duewall-Newberry site, Brazos County, Texas. In R. Bonnichsen & M. Sorg (eds.), *Bone Modification*: 413-430. Orono: Center for the Study of the First Americans, University of Maine.

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Mammoth tusk processing using the knapping technique in the Upper Paleolithic of the Central Russian Plain

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SUMMARY: The utilization of mammoth tusks as a raw material for hunting weapons, tools, decoration and art, is one of the most characteristic features of Upper Paleolithic sites in the Central Russian Plain (25-12 Ka BP). My study of 18 collections of bone and ivory artefacts (more than 2000 specimens) from Kostenki 1, Avdeevo, Khotylevo 2, Gagarino, Eliseevichi 1, Suponevo, Timonovka 1, and Yudinovo suggests that experienced craftmanship was required to carry out tusk processing. Suprisingly, sawing, cutting or chopping techniques were not used (as previously interpreted), to break the tusk into smaller fragments, but employed to produce grooves which enabled subsequent splitting processes to be more carefully controlled. Proportions and sizes of the final artefacts were predetermined by the products of the initial splitting of the tusk.

1. PROBLEMS INVOLVED IN INVESTIGATING MAMMOTH TUSK PROCESSING

The use of mammoth tusks as a raw material for the production of weapons and mobile arts is one of the characteristics of Upper Paleolithic sites in the Central Russian Plain (25 – 12 ka). In the first stage of processing, the tusk was usually divided. This procedure was more effectively conducted during *knapping*. Knapping resulted in the formation of cracks inside the tusk, along which the tusk divided, a method, which was recognized many years, ago (Gvozdover 1953, Semenov 1957, Abramova & Grigorieva 1997 *et al.*).

Studies of tusk processing during this period are based on analytical method suggested by S.A. Semenov in the 1950's. His method was based on studies of the traces of flint tools on bones artefacts which resulted from various techniques of bone processing, namely sawing, cutting, and chiselling transverse and longitudinal grooves (Semenov 1957: 175-194). However, this system made it difficult to understand the association between the processes of production involved from the first splitting of the tusk until the final stages of working.

Even when finds from a single site are analysed it is very difficult to identify the methods used to divide the tusk initially with the final shape of the objects (see for example, Hahn 1992: 120-123).

The special study of more than 2000 tusk-artefacts with traces of splitting in archaeological collections from the Upper Paleolithic sites of Avdeevo, Kostenki 1, I, Khotylevo II, Gagarino, Kostenki 4, Yelisseyevichi 1 and 2, Timonovka 1, Yudinovo and Suponevo showed, that initial tusk splitting is the most difficult part of the process and includes more stages than it was previously thought. It is the complexity of initial splitting techniques that makes it worthwhile to examine this part of tusk processing as a special technology.

2. METHODS OF RESEARCH

Our ideas about tusk splitting techniques are based on the final form of the artefacts. Assemblages of artefacts from each of the sites considered were analysed separately as were artefacts from different levels at Avdeevo and Kostenki 1 (layer 1). My special attention was given to artefacts with a common archaeological context, in other words those that were found in areas of occupation horizons where

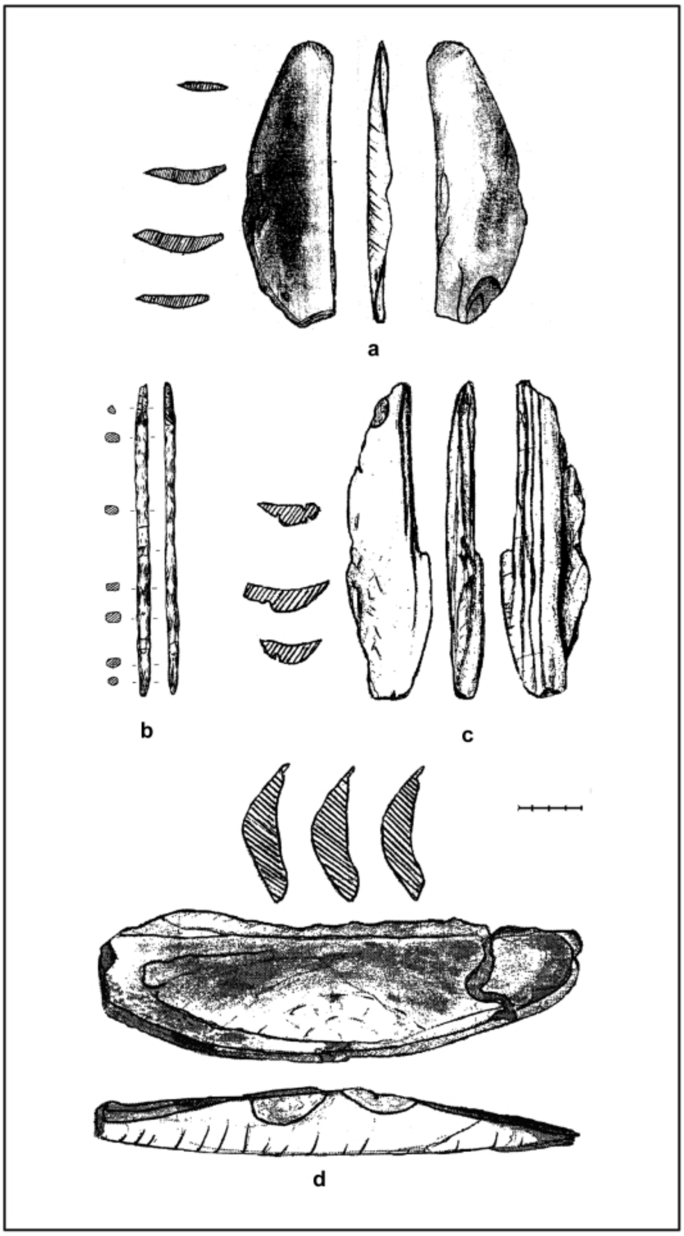

Fig.1 - Bone artefacts obtained from transverse flakes.

the initial processing of the tusk had been carried out. A comparative analysis of experimentally produced tusk artefacts, with artefacts found at Timonovka 1, Yelissevitchi 1, Yudinovo, Suponevo and Gagarino, permitted us to postulate the presence of initial tusk splitting areas at these sites. For example, I proposed the presence of such an area at Yelisseyevitchi 1. This area corresponded to a pit reconstructed by L.V. Grehova (Grehova 1993).

The description of the splitting methods included: 1) selection of tusk-fragments produced during initial splitting located within a half-closed complex; 2) The definition of morphological balance between the tusk-basis versus knapping products (positive-negative) and the intentional character of their splitting. Special attention was paid to negatives produced by splitting along cracks. These negatives did not appear as a result of the natural splitting of the tusk. Traces connected with the formation of the striking platform and the edges of the knapping fragment were also considered in detail.

The reconstruction of the chain operatoire of the initial knapping stage was based on the study of tusk-cores - the fragments of the tusks with negatives. The tusk-cores enabled us to trace connections between the knapping methods, core preparation, shape of the preparation platform and its position within the tusk.

3. TUSK KNAPPING TECHNOLOGY

3.1 Defining the term

Breakage patterns in tusks are always consistent regardless of the agent of fracturation: human or natural conditions. Anthropogenically induced fracturing is however characterised by its logical sequence of operations. There are many indications for this: control of the cracks in the material, deliberate use of this method to obtain a preconceived shape and size of the final product. Only when this is finally proven, can we refer to a knapping technology. In my opinion knapping technology is a materialized thinking algorithm, which is based on one side on knowledge of knapping possibilities and on the other on the existing cultural requirements to the shape of artifacts.

3.2 Specific features

The study of tusk knapping technology is currently less evolved than flint knapping studies. This is connected with the special particular attributes of of tusk-knapping technology. That is the reason why terminology common to flint knapping cannot be used. Tusk knapping technology differs in four aspects from flint knapping:

1. Tusk-knapping is influenced not only by mechanical force, but also by the internal structure of the tusk.

Tusk-knapping causes the fracture of the tusk into separate cone-shaped structures, recognised by all archeologists. The transverse section of the fractured tusk consists of concentric rings and longitudinal sections – “sugar-loaf cones”. This structure is a repetition of the microstructure of the dentine at macrolevel. In biology specific cone-shapes are referred to as “blades”, and result from the spontaneous stratification (= cleavage) of the tusk along the Shreger lines.

Stratification is the natural separation of the tusk into separate cone-shaped structures, due to the internal structure of the tusk.

2. Tusk-knapping could be carried out using two different modes. The first mode employs traditional techniques of flaking.

Flaking is a form of intentional knapping, where the crack inside the tusk was located close to the exterior shift and the obliged terms for its appearing were the outstanding core and the sharp corner between the platform and the flaking surface.

The second mode is referred to in this study as “breaking”. Breaking utilises the naturally occurring resistance of the tusk, brought about by its morphology (the elongated form, differences between the cement layer and the dentine core, the microstructure (Shreger lines). Mechanical force creates tension. Fracture occurs at the place where the tension is highest.

Breaking is a form of intentional knapping, resulting in a crack penetrating deeply into the core of the tusk produced by two blows performed simultaneously on the outer surface in different directions.

3. The control over tusk-knapping was reached not through total transformations of the material but through skilled correction of natural tusk-shape. Such a correction was attained through making cracks or grooves on tusk exterior surface. The form of the groove and its orientation were intentionally produced and were not dependent on the structure of the raw material. Cut, sawed or gouged grooves functioned

as a sort of striking platform on the curved surface of the tusk, which if necessary could be used to strengthen the frontal surface of the base of the tusk.

4. Depending on the different mode of knapping, knapping products posessing a more definite geometrical form could be produced.

There are to main categories of geometrical forms: flat and rodshaped. Flat artefacts possess two opposing surfaces producing a wide thin artefact. *Rodshaped* pieces are long but equal in thickness and width.

The technology of tusk-knapping is the process of the deliberate and controlled division of fragments from mammoth tusks by flaking, breaking or stratification, which the intention of producing flat and rodshaped artefacts.

3.3 Debitage products

A range of forms among the flat and rodshaped artefacts enables us to divide them into separate categories each with their own technomorphological characteristics.

Techo-morphological characteristics are a collection of macrotraces, showing specific traits corresponding to the knapping technique employed. These traits depend firstly on the mode of knapping and secondly on the direction of the impact on the tusk.

The following example illustrates the relationship between the form of traditional artefacts made of ivory and knapping technologies.

The assemblage of modified bones from the site of Yelissevitchi 1 (17-13 Kyr) contains some 30 trasverse ivory flakes, many of which are decorated with geometric designs known as Yeliseevitchi churings. The transverse flake is a flake, which results from knapping directed across the longest axis of an artefact (Fig. 1d). A deep, V-shaped, longitudinal groove functioned as a platform for its removal. The ring-shaped structure of the tusk is preserved in the form of the base of this flake. The strong force of the impact has produced a fan-shaped flake. The bulbus marks the place where the flake is at its thickest. The flake becomes progressively thinner towards its edges. These morphometric traits can be clearly observed on artefacts produced from transverse flakes, such as several oval shaped rods (Figs. 1b, 1c) and knives (Fig. 1a), artefacts of irregular oval form with a straight worked edge opposite a sharp arch-like edge (Khlopatchev 1994).

4. REFERENCES

Abramova, Z.A. & Grigirieva, G.V. 1997. *Verhnepaleolititcheskoye poseleniye Yudnovo (Upper Paleolithic settlement Ydinovo)*. St-Petersburg.

Grekhova, L.V. 1993. An attempt of reconstruction of the lost plan of the Palaeolithic site Yeliseevichi (1935) according to archivs data. *Rossiyskaya arkheologiya* 3: 173-182.

Gvozdover, M.D. 1953 Obrabotka kosty i kostyanyje izdelija Avdeyevskoy stoyanky (Prosessing bones and bone articles from Avdeevo site). *Materialy i issledovaniya po arkheologyi SSSR* 39: 192-226.

Hahn, J. 1992. Les ivoires en Allemagne: débitage, façonnage et utilisation au Paléolithique supérieur. *Le travail et l`usage de l`ivoire au Paléolithique supérieur*: 115-136. Ravello.

Khlopatchev, G.A. 1994. The morphological features of 4 ornamented blades of the churing group from the Upper Palaeolithic site Eliseevitchi 1. *Cultural translations*: 157-159. St-Peterburg: St.-Petersburg State University.

Semenov, S.A. 1957. *Pervobitnaya technika* 54. Moskow-Leningrad: Academy of Sciences SSSR.

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The production of Upper Palaeolithic mammoth bone artifacts from southwestern Germany

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SUMMARY: This analysis discusses mammoth (*Mammuthus primigenius*) remains from the Aurignacian layers at the Geissenklösterle and from the Gravettian layers at the caves of Geissenklösterle, Hohle Fels and Brillenhöhle. All the caves are situated in the Ach Valley between Blaubeuren and Schelklingen in the Swabian Jura. The role of mammoth is often underestimated at central European sites, simply because its remains are less abundant here than at Upper Palaeolithic sites in eastern Europe and Russia. But the selection of specific elements of mammoth shows the importance of this species as a raw material for the manufacture of tools. Mammoth ribs and ivory are the predominant elements of mammoth at these sites. The great length of mammoth ribs and tusks was an important advantage in the production of projectile points. This contribution emphasizes the importance of including bone tools into archaeozoological analyses, as opposed to examining them simply as artefacts.

1. Introduction

The region of the Ach Valley has a long history of research conducted by the Institute of Prehistory and Archaeology of the Middle Ages at the University of Tübingen. During the last decades, this research focused on the Geissenklösterle and Hohle Fels sites. Other important cave sites in the Ach Valley are the Grosse Grotte (Wagner 1983, Weinstock 1999), the Brillenhöhle (Riek 1973, Boessneck & v. d. Driesch 1973) and the Sirgenstein (Schmidt 1912).

The analysis of the Geissenklösterle fauna was recently completed (Münzel *et al.* 1994, 1997, 1999) and an analysis of the Hohle Fels fauna is currently being undertaken.

1.1 The Geissenklösterle-Cave

The Geissenklösterle is part of a limestone massive, a rock formation which rises 60 m above the valley bottom, and which was 10 m deeper during the Pleistocene. Excavations at Geissenklösterle were initiated in 1973 when E. Wagner (Landesdenkmalamt) opened up a test-ditch, and were continued from 1974 until 1991 by J. Hahn (1988). The site has provided a stratigraphic sequence from at least 43,000 up to 10,000 BP. The deepest layer exposed so far contains finds from the Middle Palaeolithic (AH IV), stratified above this is a Lower Aurignacian (AH III) layer (dated to ca. 38,400 BP - ^{14}C-accelerator method (AMS) and ca. 40,200 BP -thermoluminescence (TL), Richter *et al.* 2000), followed by the Upper Aurignacian (AH II, with split based points), which was dated by ^{14}C-AMS to ca. 33,500 BP and with TL to ca. 37,000 BP (Richter *et al.* 2000). The Upper Aurignacian layer (AH II) has produced four carved ivory figurines depicting a human, a mammoth, a (cave) bear and a bison. A limestone pebble painted with three colours, as well as ivory beads, perforated and dyed fish vertebrae and ornamented objects of antler and ivory were also found. More recently, fragments of two flutes made from the bones of birds were recovered in wet-sieved samples and could be reconstructed. The more intact flute was manufactured from the radius of a swan, probably a Whooper swan (*Cygnus cygnus*) (Hahn & Münzel 1995, Münzel *et al.*, in press).

The horizon above the Upper Aurignacian contains a Gravettian (AH I) occupation with several living floors (^{14}C AMS date ca. 27-29,000 BP). After the Gravettian there appears to have been a hiatus in the occupation of Southwestern Germany, probably caused by the Last Glacial Maximum. A small fireplace (^{14}C AMS date ca. 13,000 BP) is the only evidence of a Magdalénian occupation of the cave.

The large mammal species in the Geissenklösterle represent a diverse faunal spectrum and are indicative of the "Mammoth steppe environment". Prior to the Last Glacial Maximum there are no significant differences in either species composition or species representation in the faunas from the three main occupational layers in the Geissenklösterle. Alongside cave bear, which is the best represented species in nearly all the caves in the Swabian Alb, the most frequent game animals are horse, mammoth and reindeer.

1.2 The Hohle Fels Cave

The Hohle Fels, located some 2 kms from the Geissenklösterle, is one of the largest caves in the Swabian Alb, with a history of research dating back to the 1870s. Since 1977, J. Hahn conducted excavations in a niche of the entrance tunnel (Hahn 1977, Hahn & Waiblinger 1997), and after Hahn's death in 1997 these investigations were continued by N. Conard and H.-P. Uerpmann (Conard, Langguth & Uerpmann 1999, 2000). The palaeolithic stratigraphy begins with the Magdalénian (AH I), which is dated to around 13000 BP, followed by three Gravettian horizons (AH IIb, IIc, IId) dated to between 25-29,000 BP. An Early Upper Palaeolithic industry (AH III, IV, ca. 31,000 BP). was recovered in the oldest deposits exposed so far at the site. Excavations in 1997-2000 recovered a stone fragment decorated with red dotted lines from the Magdalénian (Conard & Floss 1999, Conard & Uerpmann 2000) as well as a small head of a horse which was part of an ivory figurine and dates to around 30,000 BP (Conard & Floss 2000). A silex projectile point embedded in the vertebra of a cave bear found in the Gravettian deposits gives indisputable proof of the hunting of cave bears in the caves of the Swabian Alb (Münzel, Langguth, Conard & Uerpmann, in press).

2. MATERIAL AND METHOD

The role of mammoth is often underestimated in central European sites, simply because its remains are less abundant than at Upper Paleolithic sites in eastern Europe and Russia. One reason for the underestimation of mammoth remains is their fragmentary condition and the difficulty in identifying these bone fragments. Another reason is the use of inadequate quantitative methods. The use of minimum number of individuals (MNI) is very common in quantitative analyses, but is not an appropriate method for the highly processed faunal remains at sites with dense occupation "floors" such as Geissenklösterle and Hohle Fels. MNI's and other quantitative methods based on articular ends mainly reflect the taphonomic survival of certain elements or bone parts (Brain 1967, 1969) and not their value or importance for the Palaeolithic hunter.

Therefore, this analysis uses bone weight to compare the mass of different species brought into the site, a method which was introduced by Uerpmann in the 1970s (1973). This method is a useful quantitative tool not only for species representation, but also for skeletal element representation. For the skeletal element analysis bone weight highlights under- and overrepresented elements respectively in comparison to a standard individual (Münzel 1988).

3. RESULTS

The bone weight analysis of the Geissenklösterle fauna shows that mammoth is the most important game animal after the horse. The element representation of the mammoth remains is highly biased. Mammoth ribs and ribs of rhino-mammoth size predominate in the Gravettian (AH I).

Fig.1 - Two rib fragments of rhino-mammoth size showing notches along the edges, Geissenklösterle AH1.

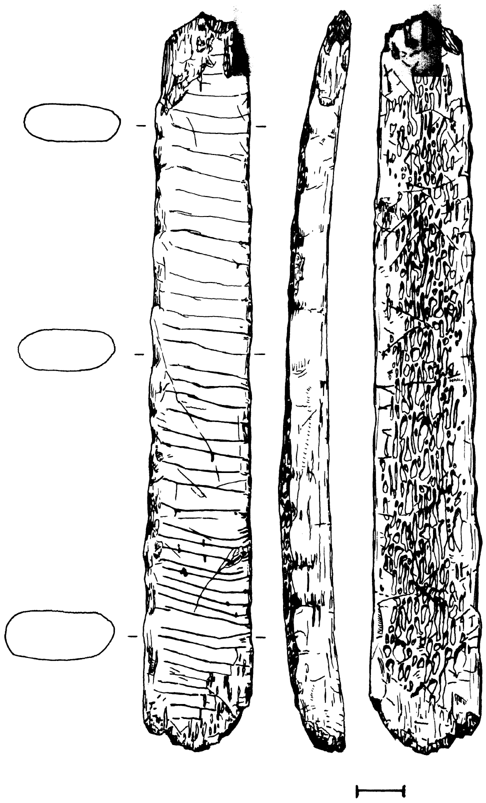

Fig.2 - Skin smoother made from a rhino-mammoth sized rib, Hohlefels AH II c.

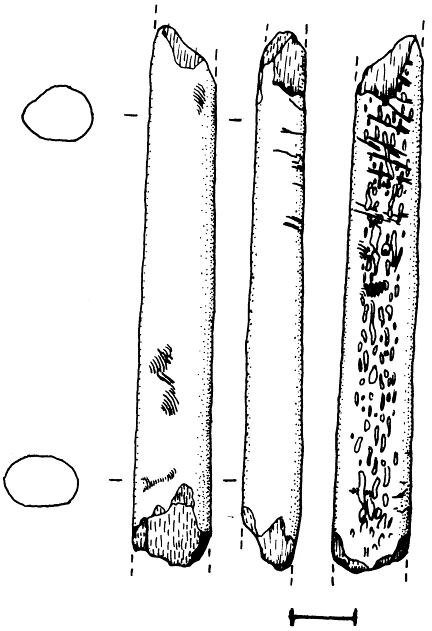

Fig.3 - Bone point made from a rhino-mammoth sized rib, Hohlefels AH II c.

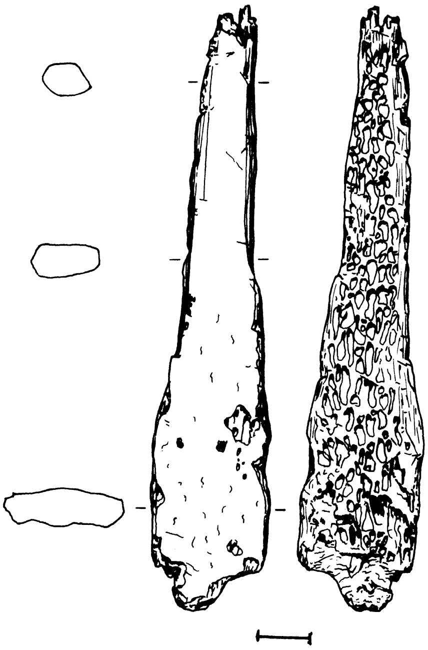

Fig.4 - Rejected base part of a bone point, Geissenklösterle AH I.

In the Aurignacian layer (AH II), remains of several very young mammoths were found, including skull fragments, milk tusks, foot bones and finger bones. These remains are from at least three infants of ca. 2 months of age (see poster: Seasonal hunting of mammoth in the Ach Valley). In addition, ivory and ribs of older individuals are present. In the Early Aurignacian layer (AH III) mammoth is represented almost exclusively by ivory, but also by ribs of mammoth-rhino size, while in the Middle Palaeolithic layer no remains of mammoth have been found so far. Perhaps continued excavation of the Middle Paleolithic layer over a larger area will produce mammoth remains.

A similar situation was recorded at Sirgenstein (AH VII-VIII, Early Late Moustérian) and Grosse Grotte (AH II, Moustérian with leaflet points), where only a few remains of mammoth were recovered from the Middle Paleolithic layers at these sites.

To conclude, ribs and ivory are the predominant elements of mammoth in all the layers discussed here. In terms of identifiability these are also easily identifiable elements. On the other hand, it is obvious that ivory and ribs were the preferred raw material for manufacturing tools.

During the Gravettian, mammoth ribs were preferred for the production of long bone points, and this is a characteristic feature in the Gravettian layers of Geissenklösterle, Hohle Fels and Brillenhöhle. According to Knecht (1991) the distribution of these “mammoth rib points” is temporally and regionally limited to Gravettien sites in South Germany. All of the thick bone points show on one side the spongiosa as well as the compacta typical of mammoth ribs. The ribs were processed in a standardized fashion. First they were notched along the edges on both sides (Fig. 1) to facilitate splitting afterwards. After splitting, the ribs were either used as a skin smoother (Fig. 2) or manufactured into points (Fig. 3). To thin the split rib halves, they were planed along the edges and smoothed on both dorsal and ventral sides until they developed a typical circular or oval cross-section. At the Geissenklösterle all stages of this “*chain operatoire*” were found: the ribs with notches, split rib pieces, partly finished products, rejected base parts (Fig. 4) and even the bone spalls produced when planing and smoothing the points. The length of the mammoth ribs and their straightness is an important pre-requisite for the production of points and lances.

In the Aurignacian layers at Geissenklösterle the typical Aurignacian points with split bases were made from reindeer antler, but the long projectile points from ivory. Obviously mammoth ribs were not favoured for these purposes in the Aurignacian, even if the splitting of ribs is a much easier task than the, technically more complicated, sectioning of tusks into segments and baguettes and the shaping of ivory points. The technology of producing these long ivory points and lances is still not quite understood (Christensen 1996, Liolios 1999). Hahn (1986) suggested that the grooving technique used to produce long spalls has still not been proven for the Aurignacian.

Why did this change in the use of the raw material for long projectile points occur? Is it a technical aspect of the technology of weapons or was it simply due to a shortage of ivory in the Gravettian?

In all three main occupation layers at Geissenklösterle (AH I, II and III), remains of individuals of very young mammoths occurred, which must have been hunted together with their mothers in spring/early summer. Thus, although the raw material situation was probably the same in all the cultural horizons, different skeletal elements were preferably brought to the site for the manufacture of the long projectile points or lances. On the other hand the repeated hunting of cows and calves might have also endangered the local mammoth population in this area where mammoths were not as frequent as in the eastern European areas of its distribution.

4. CONCLUSIONS

The Geissenklösterle faunal analysis shows that mammoth skeletal elements important for tool manufacture are predominant at the site. Other game animals, such as horse and reindeer, show similar patterns.

Due to the presence of large hearth areas with thick layers of burned bone, particularly in the AH II layer at Geissenklösterle, and at other cave sites in the Ach Valley, and the fact that those elements of bone left behind at the site are the ones useful for tool production, we conclude that since wood was rare, the bulk of the bone refuse was used as fuel.

A detailed archaeozoological analysis including the provenance of the organic artefacts is necessary for the understanding of the sites in the Ach Valley and elsewhere. The results show that during the Aurignacian and Gravettian periods, mammoth was an important resource in the Ach Valley. Even if the remains of these animals are less frequent at sites in this region in comparison to sites in eastern Europe and Russia, the mammoth rib tool production and the well developed ivory industry at the Geissenklösterle demonstrate the importance of this species during the Upper Palaeolithic in Southwestern Germany.

5. References

Boessneck, J. & von den Driesch, A. 1973. Die jungpleistozänen Tierknochenfunde aus der Brillenhöhle. In G. Rick (ed.) *Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). Forsch. u. Ber. z. Vor- und Frühgesch. in Baden-Würt-temberg* 4/II. Stuttgart: Müller & Gräff.

Brain, C.K. 1967. Hottentot food remains and their bearing on the interpretation of fossil bone assemblages. *Scientific papers of the Namib Desert Research Station* 32: 1-11.

Brain, C.K. 1969. The contribution of the Namib Desert Hottentots to an understanding of Australopithecine bone accumulations. *Scientific papers of the Namib Desert Research Station* 39: 13-22.

Conard, N.J. & Floss, H. 1999. Une pierre peinte du Hohle Fels (Baden-Württemberg, Allemagne) et la question de l'art pariétal paléolithique en Europe centrale. *Paleo* 11: 167-176.

Conard, N.J. & Floss, H. 2000. Eine Elfenbeinplastik vom Hohle Fels bei Schelklingen und ihre Bedeutung für die Entwicklung des Jungpaläolithikums in Südwestdeutschland. *Arch. Korr.* 30: 473-480.

Conard, N.J., Langguth, K. & Uerpmann, H.-P. 2000. Die Grabungen 1999 in den Gravettienschichten des Hohle Fels bei Schelklingen, Alb-Donau-Kreis. *Arch. Ausgrabungen in Baden-Württemberg 1999*: 21-25.

Conard, N.J., Langguth, K. & Uerpmann, H.-P. in Press. Die Grabungen 2000 in den Gravettienschichten des Hohle Fels bei Schelklingen, Alb-Donau-Kreis. *Archäologische Ausgrabungen in Baden-Württemberg 2000*.

Conard, N.J. & Uerpmann, H.-P. 1999: Die Grabungen 1997 und 1998 im Hohle Fels bei Schelklingen, Alb-Donau-Kreis. *Ausgrabungen in Baden-Württemberg 1998*: 47-52.

Conard, N. & Uerpmann, H.-P. 2000. New Evidence for Paleolithic Rock Painting in Central Europe. *Current Anthropology* 41, 5: 853-856.

Christensen, M. 1996. Un exemple de travail de l'ivoire du paléolithique allemand: apport de l'étude fonctionnelle des outils aurignaciens de Geissenklösterle. *Techne* 3: 39-53.

Hahn, J. 1977. Nachgrabungen im Hohlen Felsen bei Schelklingen, Alb-Donau-Kreis. *Arch. Korr.* 7: 241-248.

Hahn, J. 1986: Kraft und Aggression. Die Botschaft der Eiszeitkunst im Aurignacien Süddeutschlands? *Archaeologica Venatoria* 7.

Hahn, J. 1988. Die Geissenklösterle-Höhle im Achtal bei Blau-beuren I. *Forsch. u. Ber. zur Vor- und Frühgesch. in Baden-Württemberg* 26. Stuttgart.

Hahn, J. & Münzel, S.C. 1995. Knochenflöten aus dem Aurignacien des Geißenklösterle bei Blaubeuren, Alb-Donau-Kreis. *Fundb. aus Baden-Württemberg* 20: 1-12.

Hahn, J & Waiblinger, J. 1997. Ein Gravettien-Fundhorizont im Hohle Fels. Arch. *Ausgrabungen in Baden-Württemberg 1996*: 27-29.

Knecht, H. 1991. *Technological Innovation and*

Design during the Early Upper Paleolithic: A Sudy of Organic Projectile Technologies. Dissertation, New York.

Liolios, D. 1999. *Variabilité et characteristiques du travail des matieres osseuses au debut de l'Aurignacien: Approche technologique et economique*. Thèse de doctorat. Université de Paris X-Nanterre, Octobre 1999.

Münzel, S.C. 1988. Quantitative analysis and archaeological site interpretation. *Archaeozoologia* II (1.2): 93-109.

Münzel, S.C. 1997. Seasonal Activities of Human and Non-human Inhabitants of the Geißenklösterle-Cave near Blaubeuren, Alb-Danube District. *Anthropozoologica* 25/26: 355-361.

Münzel, S.C. 1999. *DFG-Abschlußbericht zur Großsäugerfauna im Geißenklösterle.* Unpublished manuscript.

Münzel, S.C., Langguth, K., Conard N.J. & Uerpmann, H.P. (in press). *Höhlenbärenjagd auf der Schwäbischen Alb vor 30.000 Jahren*. Arch. Korr.

Münzel, S.C., Morel, Ph. & Hahn, J. 1994. Jungpleistozäne Tierreste aus der Geißenklösterle-Höhle bei Blaubeuren. *Fundb. aus Baden-Württemberg* 19/1: 63-93.

Münzel, S.C., Seeberger, F. & Hein, W. (in press). The Geissenklösterle-Flute – Discovery, Examination, Experiments. In Hickmann, E. & Eichmann, R. (eds.). *Proc. of the 2nd Symposium of the International Study Group on Music Archaeology held in Kloster Michaelstein, 17-24 September 2000.*

Richter, D., Waiblinger, J., Rink, W.J. & Wagner, G.A. 2000. Thermoluminescence, Electron Spin Resonance and ^{14}C-dating of the Late Middle and Early Upper Palaeolithic Site Geissenklösterle Cave in Southern Germany. *Journal of Archaeological Science* 27: 71-89.

Riek, G., 1973. Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). *Forsch. u. Ber. z. Vor- und Frühgesch. in Baden-Württemberg* 4/I. Stuttgart.

Schmidt, R.R. 1912. *Die Diluviale Vorzeit in Deutschland*.

Uerpmann, H.-P., 1973. Ein Beitrag zur Methodik der wirt-schaftshistorischen Auswertung von Tierfunden aus Siedlungen. In H. Matolcsi (ed.), *Domestika-tionsforschung und Geschichte der Haustiere*: 391-395. Budapest.

Wagner, E. 1983. Das Mittelpaläolithikum der Großen Grotte bei Blaubeuren (Alb-Donau-Kreis). *Forsch. u. Ber. Vor- u. Frühgesch. Baden-Württemberg* 16. Stuttgat.

Weinstock, J. 1999. The Upper Pleistocene mammalian fauna from the Große Grotte near Blaubeuren (southwestern Germany). *Stuttgarter Beitr. Naturk.*, B, 277: 1-49.

The utilisation of mammoth remains as raw material and its importance for the Gravettian people of the German Danube

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SUMMARY: The upper Danube valley is discussed as a migration corridor both for animals and humans as well as a preferred habitat of mammoth until crossing the Swabian Jura. It could be shown that mammoth played an important role not only as a subsistence component but also as a raw material source in all gravettian cave sites along the upper Danube, sometimes also in a fossil or subfossil sate. Mainly the value of ivory is observed. Due to the high risk for mammoth hunting the seasonal aggregation of several social units in the Achtal is focussed on its geographical situation as a terminal point of the main mammoth migration with probably only small herds.

1. INTRODUCTION

The Danube was always an important migration corridor both for animals and for humans. This corridor connected the Eastern Hungarian plains to the Western Austrian and German parts of the Danube valley. The Danube plains extend up to the Viennese basin. Behind this basin the Danube flows in a narrow valley to the West, where it broadens once again behind until it reaches Krems. At this point, the valley becomes narrow and rebroadens only with the Northern "Alpenvorland", where it is bordered to the North by the Bavarian Forest, and finally by the Bavarian and Swabian Jura. To the West of Ulm the river valley narrows and at this point the volume of water in the river is strongly reduced: after this the Danube crosses the Swabian Jura in a narrow valley.

With one exception located on the left bank of the river, all of the archaeological sites described in this paper are situated in side valleys nearby the Danube. In South-Western Germany the Gravettian is mainly known from cave sites with a concentration in the Ach valley: Geissenklösterle, Brillenhöhle, Hohlefels and Sirgenstein (Scheer 1994). The Bockstein –Törle site is located in the Lone valley not far away to the North-East of the Ach valley. The Weinberghöhle, Klausen Höhlen and Abri im Dorf sites are located downstream. Only one open-air site at Salching is known along the german Danube, situated on the right river bank. New AMS dates sampled at the Geissenklösterle and Hohle Fels Caves and ranging between 27 and 29 ky (Hahn 1995) unambiguously attribute the sites in the Ach valley, as well as the Weinberghöhle and Salching, to the early Gravettian. Refitting of stone tools have definitely shown that at least three of the Ach valley caves were occupied contemporaneously during a short period of the Gravettian (Scheer 1990). This early phase of the Gravettian is characterised by ivory pendants, flechettes and some rare shouldered points or tanged Font Robert points (Scheer 2000). However at the Bockstein Törle (Hahn 2000) and probably at the Klausen Höhle (Hedges *et al.* 1997) a late phase of the Gravettian with flat-faced burins but also dihedral burins and pendants of ivory and stone is represented. The stratigraphical position of Klausen Höhle and Abri im Dorf is unclear. The early phase of the Gravettian belongs to the end of an interstadial, probably the Kesselt/Maisière oscillation or the succeeding colder phase of the l'inter Maisière Tursac (Djindjian & Bosselin 1994). Based on climatic evidence the cold-temperate, probably not too humid continental climate indicated tundra-like grasslands with a low percentage of copswood and sparse trees and shrubs, along with moorlands and some open waters on the kastic plateaux of the Swabian and Bavarian Jura.

2. EVIDENCE AND IMPORTANCE OF MAMMOTH

According to Vereschagin & Barishnikov (1982) mammoths were moving above all in broad river valleys or lacustrine environments. The Hungarian plains up to the Viennese Basin and probably Krems could be characterised as the preferred habitats of mammoths, as suggested also by Oliva (2000). A few mammoth herds certainly migrated through the narrow valley of Austrian Alpes reaching the broad Alpenvorland. The narrowing of the Danube valley to the West of Ulm presumably marked the boundary of the mammoths habitat.

Due to selection by humans faunal remains at archaeological sites do not represent the natural composition of the fauna. Even when we assume that hunting took place close to the settlements, archaeological faunas can only give an indication of the local faunal composition. Relatively high percentages of mammoth bones are present mainly in the Weinberghöhle, but also at Geissenklösterle (Table 1). In a recent faunal analysis Münzel (1997, 1999) has shown that the weight of bones identified taxonomically as mammoth and identified to mammoth-woolly rhino in size, dominate the total weight of large mammal bones at Geissenklösterle and are therefore considered to represent the most important component in the archaeological fauna followed by horse and reindeer. This is true considering the amount of meat but certainly not in terms of hunting frequency.

The remains of the species were differentially utilised. Among other hints cut marks on cave bear bones indicate hunting of the species and a comparatively higher exploitation of bear remains - more than expected. The highest counts of butchering marks were recorded on bones of mammoth and horse (Münzel 1999). Mammoth and reindeer provided not only a source of meat, but their bones, tusks and antler were used as raw material.

The skeletal material found in the caves represents the remains of hunted prey modified by butchering, choice of portions of the carcasses for transportation (since carcass portions had to be transported until 90 m from the bottom of the valley to the caves), charring of the bones, and loss of bone during carnivore gnawing ac-

Tab. 1 - Large mammal fauna from the Gravettian layers of the Brillenhöhle, Hohle Fels (HF), Weinberghöhle (WH) and Geißenklösterle (MNI of GK only teeth).

	Brillenhöhle						HF	WH	Geißenklösterle		
	quantity %			MNI			MNI	MNI	MNI	quantity%	weight%
species	V	VI	VII	V	VI	VII				I	
Ursus spelaeus	28,0	41,7	31,8	11	18	27	7	6	69	30,9	37,7
Canis lupus	1,2	0,9	0,3	1	1	1		1	2	0,3	0,4
Vulpes sp.	5,6	5,5	7,2	4	4	14	2	5	13	2,4	1,2
Panthera spelaea	0,3	0,1		1	1						
Rangifer tarandus	7,4	4,8	6,0	3	5	6	1	2	1	4,0	9,0
Equus caballus	3,2	4,4	4,6	2	3	3			2	2,5	8,7
Bos		0,1	0,1		1	1		1			
Mammuthus primig.	0,9	0,8	1,5	1	1	2	2	6	1	2,4	14,3
Coelodonta antiquitatis							1		0	0,1	0,2
Capra ibex	0,9	1,2	1,0	2		4			1	0,9	1,9
Saiga tatarica	0,3		0,2	1		2			0		
Rupicapra rupicapra			0,1			2			1	0,1	0,4
Cervus elaphus	0,3			1					1?		
Lepus sp.	34,2	21,3	27,6	6	14	22	5	9	8	5,3	2,2
total fauna	339	743	1683	70	124	262				4435	11349

tivities. The bulk of mammoth and other species remains have been deliberately modified by humans. Münzel (1999) describes the faunal assemblage from Geissenklösterle as representing the last stage of a "chaine opératoire", in other words a deliberate selection of skeletal parts as raw material for the production of artefacts. Comparative analyses of faunas from other south German Gravettian sites are lacking or are currently being undertaken. At Salching bones were not preserved. Minimum numbers of individuals are given for the Brillenhöhle (Boessneck & von den Driesch 1973), Hohler Fels (Markert 1996) and Weinberghöhle (von Koenigswald 1974). In comparison to the evidence from Geissenklösterle and especially in the Weinberghöhle, the mammoth seems relatively less frequent, but with a minimum of four individuals (MNI), an important source of meat.

The six individuals (MNI) of mammoth at the Weinberghöhle appear to indicate a certain specialisation of mammoth hunting (von Koenigswald 1974).

There is no doubt that the mammoth was an important subsistence component as shown by numerous cut marks found on its bones. The role of mammoth as a source of bone and ivory will now be discussed. For the Geissenklösterle Münzel (1999, Tab. 55) demonstrated that skeletal elements which could be used as raw material comprise between 50% to 90% of the weight of bones per species. In the case of mammoth 88% of these remains are ribs and 9% is ivory. Even when the high numbers of ivory pendants are excluded, 40% of the mammoth remains have been deliberately modified and 4.7 % bear traces of cut marks. When the non-identifiable bones of mammoth or woolly rhino size are considered, 83 % are ribs, 29% of the bones are deliberately modified and 13.5 % bear traces of cut marks. The deliberate selection of these elements of mammoth as raw material is supported by the fact that their numbers exceed the numbers of these elements in other species present. Beside bones comparable in size to those of bear or horse and those of reindeer appear to have had a certain value as a source of raw material.

In general the inventories from Geissenklösterle, Brillenhöhle, Hohle Fels and Sigenstein and even the Weinberghöhle are comparable with each other apart from some local characteristics. The lithic industry as well as characteristic bone tools such as ivory pendants (Scheer 1995), numerous projectile points with rounded bases along with "bone polishers" made of mammoth sized bones are common features of the inventories.

Ivory was of particular value. Art objects made of ivory are lacking in the Gravettian cultural levels with the exception of a questionable, not conserved venus figurine from the Brillenhöhle. Instead ivory pendants are chronological markers and regional items at the early Gravettian cave sites. The complete production sequence of standardised pendants and individual pieces is well known. These pendants could also have been made of bone or antler, of which there are a few examples. However, ivory appears to have been the preferred material. This was not due to the ease of working ivory, since if not treated ivory is more difficult to work than either bone or antler (Christensen 1999). It is highly likely that palaeolithic people knew how to soften ivory.

Whereas it is easier to work bones which are still fresh, ivory can be worked in a fossil or subfossil state. Experiments have shown that fossil ivory of mammoth, softened in water, is carvable like wood (Hahn *et al.* 1995). Some of the material used for ivory pendants appears to be fossil or subfossil ivory. A comparable analysis of tools made of bone has not been undertaken so far. The choice of ivory for the production of pendants may lie in their function. The tear-drop shaped pendants possibly mimic the canines of deer, which were rare in this region. The wearing of such pendants on the clothes probably had a symbolic character. Ivory was chosen as a raw material for this type of pendant due to its extremely homogenous, fine-grained material which could be highly polished. The presence of pendants made of fossil or subfossil ivory shows that ivory was particularly sought as a raw material for the production of pendants and cannot be considered just as debris from the tusks of hunted animals. This contradicts an interpretation of ivory as hunting trophies and might point to its symbolic character in terms of prestige, status, sex, clan etc.

It is remarkable that comparable ivory pendants are very rare in relation to the mass of available raw material at Moravian sites, where mammoth is much more abundant (Oliva 2000) and ivory preservation is very good (Oliva 1995; Kozlowski 1992). At Pavlov I and II (Absolon 1945; Klima 1976) as well as Dolni Vestonice (Klima 1983) comparable pendants were often made of stone or in other forms. The question is whether we are dealing with differing values of ivory as a raw material or different traditions along the Upper Danube. However, ivory pendants similar to those found in Southern Germany also occur in the Mamutova cave situated further to the northeast (Kozlowski 1992) indicate the presence of these pendants might be specific to caves sites.

3. CONCLUSION

For the Gravettian people along the Upper Danube mammoth was an important source of meat particularly in the Weinberghöhle. Even when fewer mammoths belong to the hunted fauna at the caves in the Ach valley, the amount of meat even from these small numbers of individuals was much larger in comparison to reindeer and horse, as indicated by the bone weight. Ribs comparable in size to those of mammoth, cave bear and horse were the most important sources of raw material for the production of bone points. Ivory plays an important role in decorative objects disproportionate to the large amount of bone and antler.

The use of fossil or subfossil ivory by the Gravettians could be due to the ease with which this material could be worked or could point to the rarity of fresh ivory, indicating that ivory was collected just like raw material for lithic production. The possibility that other skeletal elements collected from the carcasses of mammoths which had died naturally were utilised cannot be excluded.

Hunting mammoths bore a high risk for the hunters and requires a greater cooperation of social units (Oliva 2000). A seasonal aggregation of several social units is very probable in the case of the settlement of the caves in the Ach valley. The presence of similar ivory pendants in all of the caves presupposes a certain reciprocal contact. The contemporary occupation of at least three of the caves has been shown by lithic refittings. However, the inventories from each of these sites still have their own individualities. The archaeological remains suggest seasonal contact of four social units. Evidence of seasonality from the faunal remains indicates settlement between spring and early summer. Perhaps this seasonal settlement focussed on the geographical situation of the Ach valley which was the terminal point of the main mammoth migration west of Ulm. The Ach valley as well as the "Wellheimer Trockental" with the Weinberghöhle are both quite narrow valleys, where certainly only a few mammoths appeared which were relatively easy quarry for the hunters. However if hunting took place in the Danube valley, the hunters would have had to transport their prey over several kilometres. In any case mammoth reached the Danube valley or its side valleys west of Ulm. In view of the geographical and archaeological faunal evidence here mammoth were probably only present in small herds. The larger amount of mammoth remains in the Weinberghöhle may indicate either different focal point of hunting or the presence of larger herds of mammoth downstream in the broader valley of the Danube.

4. REFERENCES

Absolon, K. 1945. *Die Erforschung der diluvialien Mammutjägerstation von Unter-Wisternitz in den Pollauer Bergen in Mähren.* Arbeitsbericht über das dritte Grabungsjahr 1926, Brno.

Boessneck, J. & von den Driesch, A. 1973. Die jungpleistozänen Tierknochenfunde aus der Brillenhöhle. In G. Riek (ed.), *Das Paläolithikum der Brillenhöhle bei Blaubeuren (Schwäbische Alb). Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 4/II. Stuttgart: Mueller

& Graef.

Christensen, M. 1999. Technologie de l'ivoire au Paléolithique supérieur. Caractérisation physico-chimique du matériau et analyse fonctionelle des outils de transformation. *BAR International Series* 751.

Djindjian, F. & Bosselin, B. 1994. Périgordien et Gravettien: L'épilogue d'une contradiction? *Préhistoire européene* 6, 117-131.

Hahn, J. 1995. Neue Beschleuniger C14-Daten zum Jungpaläolithikum in Südwestdeutschland. *Eiszeitalter und Gegenwart* 45: 85-91.

Hahn, J. 2000. The Gravettian in Southwest Germany – environment and economy. In W. Roebroeks, M. Mussi, J. Svoboda & K. Fennema (eds.), *Hunters of the Golden Age. The Mid Upper Palaeolithic of Eurasia 30,000-20,000 BP*: 249-256. Leiden.

Hahn, J., Scheer, A. & Waibel, O. 1995. Gold der Eiszeit - Experimente zur Elfenbeinbearbeitung. In Scheer (ed.), *Eiszeitwerkstatt. Museumsheft 2 des Urgeschichtlichen Museums Blaubeuren*: 29-37. Blaubeuren.

Hedges, R.E.M., Pettitt, P.B., Bronk, C.R. & van Klinken, G.J. 1997. Radiocarbon dates from the Oxford AMS system. Archaeometry Datelist 25, *Archaeometry* 39: 247-262.

Klima, B. 1976. Die paläolithische Station Pavlov II. *Acta Sc. Nat.* 10, 4. Prag: Academia.

Klima, B. 1983. *Dolni Vestonice*. Taboriste lovcu mamutu: Prag: Academia.

Königswald, W. von 1974. Die pleistozäne Fauna der Weinberghöhlen bei Mauern. *Archaeologica Venatoria*, 3: 17-144.

Kozlowski, J.K. 1992. *Preistoria dell' Arte orientale Europea*. Milano.

Markert, D. 1996. Die Fauna des Hohle Fels bei Schelklingen. In I. Campen, J. Hahm & M. Uerpmann (eds.), *Spuren der Jagd - Die Jagd nach Spuren. Festschrift für H. Müller-Beck. T.M.U.* 11, 1996: 449-454. Tuebingen: MoVince.

Münzel, S.C. 1997. Seasonal Activities of Human and Non-human Inhabitants of the Geißenklösterle-Cave near Blaubeuren, Alb-Danube District. *Anthropozoologica* 25/26: 355-361.

Münzel, S.C. 1999. *DFG-Abschlußbericht zur Großsäugerfauna aus dem Geißenklösterle*. Unpublished manuscript.

Oliva, M. 1995. L'Usage de l'ivoire au Paléolithique en Tchécoslovaquie. In J. Hahn, M. Menu, Y. Taborin, Ph. Walter, & F. Widman (eds.), *Le Travail et l'usage de l'ivoire au Paléolithique supérieur*: 189-198. Roma: Istituto Poligrafico e Zecca dello Stato.

Oliva, M. 2000. Some thoughts on pavlovian adaptions and their alternatives. In W. Roebroeks, M. Mussi, J. Svoboda & K. Fennema (eds.), *Hunters of the Golden Age. The Mid Upper Palaeolithic of Eurasia 30,000-20,000 BP*: 219-229. Leiden.

Scheer, A. 1990. Livingfloors and Settlement-patterns. Refitting as an interpretativ method. In E. Cziesla *et al.* (eds.), *Studies in modern Archeology vol. 1. The Big Puzzle, International Symposium on Refitting Stone Artefacts*: 623-649.

Scheer, A. 1994. Höhlenarchäologie im Urdonautal bei Blaubeuren. *Museumsheft 1 des Urgeschichtlichen Museums Blaubeuren. Blaubeuren*.

Scheer, A. 1995. Pendeloques en ivoire durant le Gravettien en Allemagne du sud – un indice chronologique et social ? In. J. Hahn, M. Menu, Y. Taborin, Ph. Walter & F. Widman (eds.), *Le Travail et l'usage de l'ivoire au Paléolithique supérieur*: 137-171. Roma: Istituto Poligrafico e Zecca dello Stato.

Scheer, A. 2000. The Gravettian in Southwest Germany: stylistic features, raw material resources and settlement patterns. In W. Roebroeks, M. Mussi, J. Svoboda & K. Fennema (eds.), *Hunters of the Golden Age. The Mid Upper Palaeolithic of Eurasia 30,000-20,000 BP*: 257-271. Leiden.

Vereschagin, N.K. & Barishnikov, G.F. 1982. Paleoecology of the mommoth fauna in the Eurasian Arctic. In D.M. Hopkins *et al.* (eds.), *Paleoecology of Beringia*: 267-280. New York: Academic Press.

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Ivory points in the Lower Paleolithic of Europe

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SUMMARY: In 1983 Howell & Freeman published 34 ivory tusk fragments, described as points with a stem for hafting, from the Lower Paleolithic sites of Torralba and Ambrona (Spain). They viewed these pieces as evidence that the Acheulian hunters possessed techniques normally thought to be an Upper Paleolithic innovation. These pieces were later considered natural by Gary Haynes because their general morphology was similar to that of naturally broken tusk tips. Howell & Freeman have argued that various traces of human manufacture and utilization, not just the shape of the points, prove that these were artifacts. We have re-examined all the specimens of previous excavations and 27 new specimens from the recent Ambrona excavations. We use morphometric, optical and SEM microscope analysis and combine these observations with taphonomic, sedimentary and actualistic data. We conclude that all the Torralba and Ambrona pieces are natural and not evidence that mid-Pleistocene hominids made or used ivory points.

1. INTRODUCTION

The Lower Paleolithic sites of Torralba and Ambrona were first excavated at the beginning of the last century by Cerralbo. More systematic and extensive excavations at both sites were carried out by Clark Howell and Leslie Freeman between 1961 and 1963 and at Ambrona between 1980 and 1983 (Howell *et al.* 1991). In 1983 Howell & Freeman published thirty-seven ivory tusk fragments of which 34 were described as points with a stem for hafting. Cerralbo had found eight of these points in Torralba; he thought that humans had used these tusk tips. Howell & Freeman suggested that the Acheulian hunters deliberately fractured *Elephas antiquus* tusk tips by flexion producing a repetitive shape, in some cases modified by grinding and polishing and/or marginal retouch. These objects were thus considered as evidence that Lower Paleolithic people possessed techniques to produce patterned bone implements, normally thought to be an Upper Paleolithic innovation.

These pieces were later considered natural by Gary Haynes (Haynes 1991) because their general morphology was similar to that of tusk tips and medial segments found by him in various game preserves of southern Africa around dry-season water holes. Haynes suggested that breakage results from intra-specific fights or when elephants use their tusks in feeding activities or in pushing and lifting heavy objects. In a recent paper Howell *et al.* (1991) defend their interpretation of most of these points as artifacts. According to them, various traces of human manufacture and utilization (striations, grooves, polish on tip or stem, flaking, chipping and facetting) not just the shape of the points, prove that these were artifacts. They also say that some morphologies are different from those documented by Haynes.

To assess the validity of Howell and colleagues' renewed interpretation of these traces, we have re-examined all the specimens of Cerralbo and Howell & Freeman's excavations kept in Soria and in Madrid. A second reason for re-examining these ivory points is that 19 new tusk tips with a stem, 3 medial segments, 3 ivory flakes and 2 points without a stem (Fig. 1) have been found in the new excavations at Ambrona directed by Manuel Santonja and Alfredo Pérez-González. The excavations have also produced several more or less complete tusks and many annular tusk fragments that are the result of postdepositional breakage.

2. ANALYTICAL PROCEDURES

To assess the nature of modifications under study we have used three different kinds of reference materials: 1) A modern sample of eleven complete tusks of African elephants killed by poachers and illegally exported subsequently confiscated by French customs officers. The sample is stored in the Museum d'Histoire Naturelle of Bordeaux; 2) Experimental reproduction of stone tools marks on ivory using retouched and unretouched blanks; 3) Comparative data derived from observations of unbroken archaeological tusks from Ambrona, which are clearly not artifacts.

Taphonomic and sedimentary context data were available from the recent Ambrona excavations and have thrown light on questions of mechanical abrasion.

Recorded morphometric data include length, breath and thickness of points and stems. We noted the presence, location and mode of occurrence of striations, and features such as polish, degree of abrasion, micro-pitting, root marks and preparators' marks. When applicable, the same variables were recorded on the modern and archeological reference material. Each specimen was examined with a reflected light microscope; selected areas were replicated with Vinyl Polysiloxane impression material. Positive casts, made in araldite, were observed with a SEM Jeol. 840A. Transparent replicas were also observed and photographed in transmitted light with a Wild M3C stereomicroscope.

3. RESULTS

To investigate the life history of these objects we examined in sequence their breakage morphology, their dimensional variability, and various putative traces of manufacture, use and resharpening.

3.1 Breakage morphology

Contrary to Howell *et al.*'s (1991) statement that some archaeological point morphologies are different from those documented by Haynes, our analysis of the old and new points indicates that all shapes found at Torralba and Ambrona are present in Haynes' modern series, i.e. pieces with long and short stems, pieces without a stem, pieces with a dihedral end, medial tusk segments and different types of ivory flakes.

As indicated by Haynes (1991) breakage of tusk tips occurs during the animal's life. In our modern reference collection an adult tusk shows the trace of an elongated tip fracture with smoothed edges. The resulting ivory point must have been like many Torralba and Ambrona specimens, possessing a short tip and a rather long and flat stem. The rounded edges of the fracture show that the animal continued to use its tusk, smoothing out the broken surface.

3.2. Size variation

The frequency distributions of total, stem and apical length show very dispersed values. The length of intact ivory points ranges between 1.8 and 23.2 cm. Some of the smaller pieces have extremely short points (the smallest is 0.4 mm long) of no plausible functional value yet they have exactly the same general morphology as the much larger pieces. The recent excavations have added to the impression of a great dimensional variability through the recovery of several points smaller than 4 cm, missing from the older series. Thus, we agree with Haynes' suggestion that the morphology of these pieces is natural and accidental; their length and breadth variability makes them weak candidates for being hafted artifacts.

3.3 Traces of manufacture and utilization

Howell & Freeman (1983; Howell *et al.* 1991) have suggested that, although the pro-

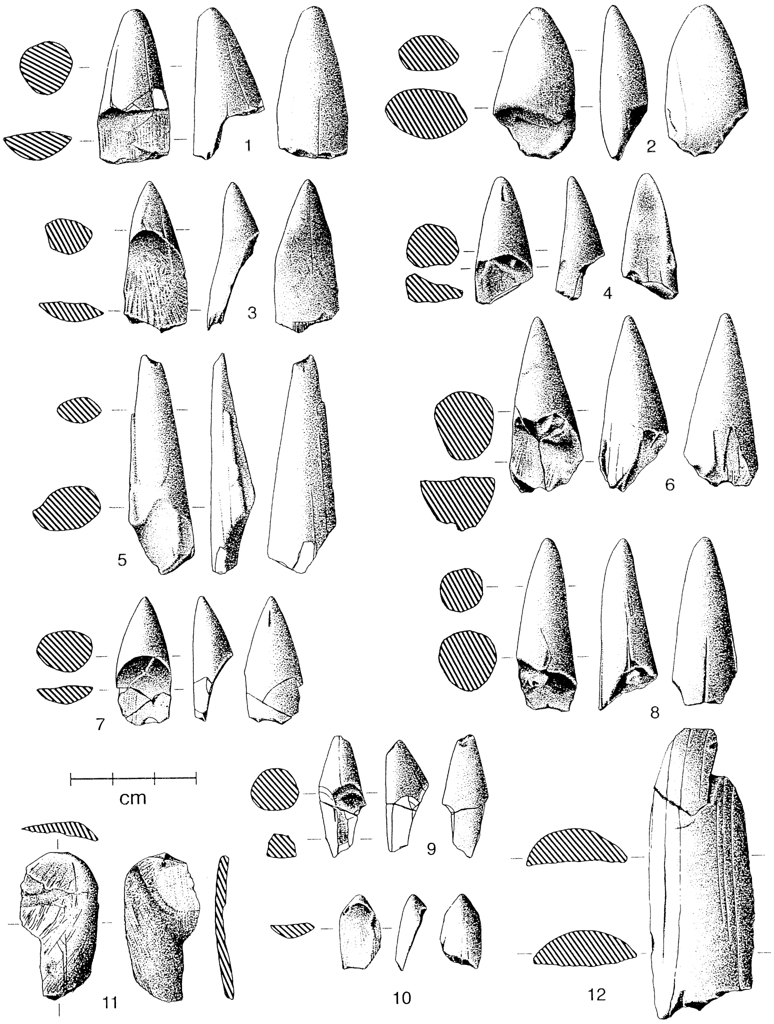

Fig.1 - Ivory points and ivory flakes from the 1993-1999 Santonja and Pérez-González' excavations.

duction of some of these pieces may be a natural phenomenon, humans have used and modified them, stressing the presence of manufacturing and utilization traces, such as striations, polish, grooves and tool marks, and marginal flaking. These traces were not discussed by Haynes. In their analysis, however, Howell and colleagues do not address the problem of the state of preservation of the surfaces. To assess the anthropic origin of these traces it is necessary to evaluate the taphonomic processes, which may have produced them. The new excavations and assemblage analysis provide data on the sedimentary context and the degree of preservation of the bone, ivory and lithic remains.

Points from the new excavations derive from four stratigraphic units: unit AS1 (alluvial fan deposits), AS1/2 (fluvial sands), AS3 (lacustrine marls with some gravels) and AS4 (channel and overbank deposits). Although the degree of abrasion of all archaeological materials varies from one unit to another, 70 to 90% of all bones, stone artifacts and ivory points show some degree of abrasion. On a total of 40 points from the old and new excavations, only

6 are fresh; 34 (i.e. 85%) are either slightly or very abraded. In some cases points are so rolled that they have almost completely lost their original shape. Frequency distributions of degrees of abrasion for different materials indicate that ivory points and bones have comparable values. Microscopic analysis of bone and ivory surfaces confirms that some at least of the surface modifications noted on these pieces are due to taphonomic processes. According to Howell & Freeman, 24 points carry striations of human origin. Our analysis of new and old points shows that all of them carry striations. In most cases points are covered with randomly oriented or intersecting sets of striations of variable width and depth. That these striations have a non-anthropic origin is strongly suggested by the fact that similar patterns of striations occur on unworked tusks from Ambrona, including on the internal face of annular tusk fragments, on the surfaces of many bones from the same site and on modern tusks. Thus, some of these striations are due to sedimentary abrasion, in particular those on the internal face of tusk annuli which are unexposed during the animal's life. Others were produced by the elephants themselves while using their tusks in a variety of activities, such as digging for tubers and water, scraping soil for salt or stripping bark from trees, as suggested by our modern sample.

Polish on tip or stem, interpreted as due to use or rubbing against the haft, was observed by Howell & Freeman on 18 pieces. Our SEM analysis of surfaces described as polished shows that they are covered by intersecting striations comparable to those present on other points with varying degree of surface and edge abrasion, indicating that areas considered as polished do not differ microscopically from naturally abraded surfaces.

Several stems present small flake scars on the sides or at the proximal end described as traces of intentional retouch or chipping by use. In fact such scars occur also on naturally broken tips collected by Haynes who considers them as damage occurring at the time of breakage. Facets described as an indication of deliberate shaping should also be considered a result of natural processes. In fact, during the elephant life the tusk tip can be broken creating flattened surfaces which are gradually smoothed and worn down forming facets with rounded edges and tips with spatulate ends.

4. CONCLUSIONS

We conclude that all the Torralba and Ambrona pieces are natural and not evidence that mid-Pleistocene hominids made or used ivory points.

The ivory point from the site of Castel di Guido (Radmilli & Boschian 1996) is very similar to those from Torralba and Ambrona. At Castel di Guido elephant remains are the most abundant after those of *Bos primigenius*. All skeletal elements are represented including 81 tusk fragments. The ivory piece is listed among the bone tools. Although the processes of accumulation of the faunal assemblage are still to be elucidated and a microscopic analysis of the object remains to be done, a natural origin of the fragment is suggested to us, as at Torralba and Ambrona, by the available data and the absence of clear anthropic modifications.

5. REFERENCES

Haynes, G. 1991. *Mammoths, Mastodonts, and Elephants*. Cambridge: Cambridge University Press.

Howell, F.C., Butzer, K.W., Freeman, L.G. & Klein, R.G. 1991. Observations on the Achelean occupation site of Ambrona (Soria province, Spain). *Jahrb. Römisch-Germanischen Zentralmus. Mainz* 38: 33-82.

Howell, F. C., & Freeman, L. G. 1983. Ivory points from the earlier Acheulean of the Spanish Meseta. In *Homenaje al Prof. Martin Almagro Basch*: 41-61, Madrid: Ministerio de Cultura.

Radmilli, A.M. & Boschian, G. 1996. *Gli scavi a Castel di Guido.* Firenze: Istituto Italiano di Preistoria e Protostoria.

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Ivory as a raw material during the Upper Palaeolithic of the northern edge of the Iberian Peninsula: personal ornaments and other artifacts

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This paper reports on the presence of ivory artifacts from Upper Palaeolithic sites of the northern edge of the Iberian Peninsula. In comparison to other European sites of the same period, tools made of mammoth ivory from Upper Palaeolithic sites in this territory are very rare. Ivory artefacts are known from the Aurignacian (La Viña, El Pendo), the Perigordian (La Viña, Cueto de la Mina), the Solutrean (La Viña , Las Caldas, Cueto de la Mina, La Riera, Llonín, Chufin, Altamira), the Magdalenian (Cueto de la Mina, Llonín, Altamira, Jarama II). In contrast, only a single ivory tool is known from the Azilian (La Riera). Sagaies, awls and shafts predominate among the artifacts that are made from this raw material, and there are also some ivory ornaments. The presence of an ivory figurine of an animal from Jarama II is noted. By referring to mobiliary art, and paintings and engravings in caves, a comparison is made between sites in this territory with ivory artifacts and those with mammoth representations.

The hunting of mammoth and the utilisation of mammoth bones and ivory in the Rhône basin

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Numerous remains of mammoth, in particular tusks and molars, have been recovered from sites in the Rhône basin. These localities comprise open sites in the loess deposits of the Gard and the Ardèche, open sites, caves and abris dating to the Middle Palaeolithic, and sites dating to the Upper Palaeolithic. Generally the remains of young individuals have been found, since these could be hunted. There are very few postcranial elements. These may have been utilised after the meat had been removed as a source of fuel, as observed at Central and Eastern European sites. During the Aurignacian, Solutrean and Magdalenian ivory was used as a raw material for pendants and for sagaies. Traces of use on the occlusal surfaces of the molars indicate that the teeth served as scapers. At Solutré (Middle Magdalenian) a mammoth humerus which had been truncated by an adze and probably served as a "support for cutting meat" was recovered amongst the butchered horse bones. The humerus displayed traces originating from the use of several flint tools.

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Mammoth cutlery: mammoth flakes for mammoth steaks

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Excavations were conducted between 1980 and 1984 at the Lange/Ferguson site, a mammoth kill-butchering locality situated on the edge of a Late Pleistocene pond or marsh in the White River Badlands of South Dakota (USA). These investigations established the presence of a Clovis technocultural complex. One human activity area at the site contained the associated remains of an adult and a juvenile mammoth. Both animals had been systematically butchered using culturally modified elements of mammoth bone. Bone flakes were deliberately removed from mammoth bone cores by Clovis hunters during the butchering process. The flakes were removed from both dorsal and ventral faces of prepared bone cores. Flake removal parallels the longitudinal axis, with several specimens exhibiting transverse flaking. SEM evaluations on several of the mammoth bone flakes as well as on other mammoth bone tools from the Lange/Ferguson assemblage, was able to document the unequivocal evidence for the utilization of these specimens in the butchering process. A second human activity area at the site, in a context stratigraphically related to the first area, revealed three Clovis points. The recovery of mammoth bone implements, coupled with the recovery of well-preserved proboscidean, non-proboscidean, and invertebrate fauna, as well as fossil pollen and phytoliths, has expanded our insights into butchering systematics associated with the Clovis culture.

Two centres of Paleolithic art in Ukraine: the mammoth bone objects

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The most ancient examples of art in the Ukraine are associated with the Upper Paleolithic and are up to 25,000 years old (Molodova V, level 8). Two groups of sites where Upper Palaeolithic art is present are known in the Middle Dnestr (Molodova 1 and 5, Korman IV, Ataky) and the Middle Dnepr (Mezin, Dobranichevka, Mezhirich and Kirillovskaya) regions. Practically all types of arts (painting, graphic arts, figurines) are present at the group of sites in the Middle Dniepr region. The most striking examples are known from Mezin (20,000 years old), where unusual forms of female figurines, treasures, sets of mammoth bones painted by red ochre have been found. A similar collection of art is known from Mezirich (graphic paintings, figurines, treasures, paintings of red ochre). At other sites such as Dobranichevka, Pushkari and Kirillovskaya some isolated figurines made from mammoth ivory (Dobranichevka), graphic paintings (Kirilovskaya), treasures (Pushkari) have been found.

The Middle Dnestr sites have poorer examples of art. More common at these sites are tools made of the bones and antlers of reindeer. Objects made of mammoth bone and ivory are rare (the head of a figurine from level 8 Molodova 5, an anthropomorphic depiction on the "bâton de commandement" from level 7 at the same site, etc).

Thus, it is possible to define two centres of Paleolithic art, different in culture, chronology and art expression.

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The variability of the utilisation of mammoth remains from assemblages at three Epigravettian sites in the northern Ukraine

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Efficient mammoth hunting by Palaeolithic humans as well as the collection of mammoth bones are issues discussed in the current literature. During the excavation of three Epigravettian sites (located close together and dated to 14-15,000 BP) in the Middle Dniepr basin, the existence of both methods of procuring mammoth remains was confirmed and new data concerning various methods of the utilization of these bones was obtained. At the Semenivka 1 kill-site a pile of 35 selected and carefully stacked bones of mammoth (tusks, pelves, shoulder blades and long bones), from a mimimum of four individuals, was revealed close to the remains of a hunted and butchered brown bear. No traces of fire were discovered, and only 4 lithics (the tip of a backed point with a projectile impact fracture, a burin, a blade and a flake) were present among these remains.

The neighbouring site of Semenivka 2 functioned as a transient seasonal camp for a larger group of Epigravettian hunters. Only the remains of mammoth (a total of 79 bones) were found, along with 200 lithic tools (backed microliths with numerous projectile impact fractures and burins) and fragments of charred bones. Fragments of ribs (47) dominate among the 54 identifiable skeletal elements of mammoth, which were undoubtedly used as food and fuel. Fragments of skulls were not found. The same situation was observed at the Semenivka 3 site (a long-term seasonal hunting camp) where a richer cultural layer with lithics, marine shells, charred bones and faunal remains (mainly mammoth and isolated bones of other species) was discovered. The artefact assemblage (including backed microliths with projectile impact fractures, fragments of slotted ivory points and burins) reflects a specialization at this site of tools for hunting. Ribs dominate the assemblage of more than 200 mammoth bones; parts of the skull are, once again, absent. The ribs were also used in some light dwelling constructions as wedges to fix wooden elements of the tents in the ground.

Proboscidean bone modification in the Middle/Upper Palaeolithic of the Japanese Islands

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Most Japanese palaeolithic sites have been found in aeolian tephra layers; the acid tephra layers preserve no organic materials at all, and over all the Japanese Islands only a few exceptions to this situation are known. The Late Middle Palaeolithic site of Tategahana, dating to OIS 3 and located on the shore line of Lake Nojiri in Central North Japan, is a unique site where numerous mammalian fossils and many palaeolithic artefacts have been recovered by archaeologists during excavation of the the lacustrine sediments. The bulk of the mammalian fossils belongs to two species. The remains of Naumann's elephant (*Palaeoloxodon naumanni*) represent 91,9%, and bones of Yabe's giant deer (*Sinomegaceros yabei*) 7,9% of the total number of mammalian fossils. This faunal assemblage suggests selective big game hunting by palaeolithic hunters according to the composition of the faunal remains. Lithic tools, such as scrapers and borers, and flakes were associated with the bones within the same layer. The bone tool inventory is made from elephant bone and comprises an oblong side scraper, a cleaver, a knife shaped tool, and flakes with retouched bases. In the Middle Nojiri-ko Member I, a bone cleaver as well as bone flakes with retouched bases, and chips of bone, which could be refitted, were found together in a concentration. This evidence suggests that some areas of the site functioned as a kill-butchering locale on the shore of the lake, implying that the elephant hunters also produced bone tools during their kill-butchering activities.

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Ivory pendants in the Belgian Palaeolithic

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The Belgian Early Upper Palaeolithic has yielded abundant traces of activities connected with the working of ivory. Sagaies with massive bases (Mladeč type) are present in all their different stages of manufacture.

However, data is particularly abundant concerning artistic objects: pendants, beads, rings, figurines. This form of activity appears to be associated with the Aurignacian. During the Gravettian (e.g. at Maisières-Canal), finely engraved and striated ivory plaquettes were produced.

Channel Islands (USA) pygmy mammoths (*Mammuthus exilis*) compared and contrasted with *M. columbi,* their continental ancestral stock

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SUMMARY: Remains of the pygmy mammoth *Mammuthus exilis* have been known on the Channel Island of California since 1856. After initial colonization of Santa Rosa Island by *M. columbi*, the process of island adaptation noted as Foster's Rule came about. After the available radiocarbon chronology, it appears that they have been there, in essentially unchanged pygmy form, for more than 47,000 years (i.e. beyond the limits of radiocarbon chronology). They may have survived until the early Holocene colonization of the islands by the ancestors of the ancient Chumash people.

With the reconsideration of the dwarf status of the woolly mammoths (*M. primigenius*) of Wrangel Island (Mol 1995; Tikhonov 1997), the only island dwelling truly diminutive mammoths are those from the Channel Islands of California. Remains of these pygmy mammoths have been known on the islands since discovered in 1856 by a coast and geodetic survey. The first publication of the animals was in a brief report in the Proceedings of the California Academy of Sciences (Stearns 1873). Further paleontological studies were conducted by the City College of Los Angeles (Stock & Furlong 1928). Sporadic field collections by the Los Angeles County Museum were halted with the advent of World War II. Phil Orr, of the Santa Barbara Museum of Natural History, collected mammoth remains in the 1950's and 1960's, to substantiate his archaeological theory that the ancestral Chumash Indians decimated the island proboscideans (Orr 1956, 1968). Orr was unable to convince his scientific peers and island paleontology met a hiatus until the 1990's with a salvage collection of a San Miguel Island specimen, by Bob Gray of Santa Barbara City College, for the National park Service (NPS). In 1994 the discovery, excavation and recovery of a nearly complete, adult, male, *M. exilis* skeleton took place (Agenbroad 1998, 1999). During the nearly 30 year hiatus between the Orr's work and the 1990's salvage excavations, amateur collecting was done by Boris Woolley, a member of the ranching families in control of Santa Rosa Island.

Beginning with the recovery of the 1994 skeleton, a methodical pedestrian survey of the islands was begun, using Global Positioning System (GPS) coordinates to pinpoint each discovery. This on-going system has produced more than 140 new mammoth localities on the three outermost islands (a new locality being defined as one or more mammoth remains that in all probability do not represent a previous location). The survey has tended to destroy some of the myths about the distribution and types of mammoth remains on the islands.

During the Pleistocene glacial advances water was held on the continents as snow, glaciers, and ice sheets. As a result, sea level was lowered by 100 to 125 m in the last major glacial cycle. The lowering of sea level exposed a large island off the coast of California, designated as ‘Santarosae’ in Phil Orr's research. Postglacial warming caused melting of the continental ice and snow, recharging the ocean, causing sea level to rise to the current position. Santarosae became gradually inundated, leaving only four islands which reflect the highest elevations of the Pleistocene ‘super island’. San Miguel, Santa Rosa, Santa Cruz, and Las Anacapas Islands are all that remain exposed of Santarosae. Seventy-six percent of the Pleistocene island is now submerged, with the last connections between the island having been inundated between 12,000 and 11,000 radiocarbon years ago. Of the four modern islands, all but Las Anacapas produce mammoth remains.

After initial colonization of Santarosae by *M. columbi*, the process of island adaptation noted as Foster’s Rule (Foster 1964) came about. Large continental mammals became smaller and small continental mammals became larger. Pleistocene Santarosae had “giant” deer mice (*Peromyscus*) and “pygmy” mammoths (*M. exilis*).

In the island survey, a ratio of approximately 1:10 large mammoth remains/small mammoth remains was encountered. All of the Columbian mammoth remains, thus far, have been located in elevated marine terrace remnants. Pygmy mammoth remains have been located in marine terraces, alluvial stream terraces, and stream channels near the island uplands. Approximately 50% of the island of Santa Rosa consists of uplands, with slopes exceeding thirty degrees. Using Columbian mammoths of Hot Springs, South Dakota as a representative continental population (Agenbroad 1994), various metric and morphological comparisons were made with the island mammoths. Calculations based on the center of gravity of large and small mammoths revealed that the pygmy mammoths were able to negotiate slopes that were as much as 10 degrees steeper than Columbian mammoths could travel. This suggests one of the reasons that the diminutive forms became the dominant island mammoth population. It should be noted that pygmy mammoths have not been discovered on the continental coast.

In 1977, Paul Sondaar, studying stegodons in Indonesia, concluded there was a shortening of lower limb bones, to allow “low gear locomotion” (akin to 4 wheel drive in modern vehicles) needed in ascending and descending steep slopes. This gave smaller animals access to upland pasturage which may have been crucial to survival in periods of climatic or dietary stress. Bone metric analyses confirm Sondaar’s conclusions for *M. exilis*, the island adapted mammoth.

Analyses of the femora, humerii and dentition reveal additional characteristics. Femora of the island mammoths are significantly longer, as contrasted to the mean of the Hot Springs Columbian mammoths, and the femoral cross section of the pygmy mammoth is more circular, as compared to the flat ellipse of the continental mammoths. Studies of humeri suggest rotation of some of the muscle functions and attachments. The humerus takes on the added use, as a braking mechanism for a quadruped descending steep slopes. Analysis of dentition has produced a plot of all molar generations, which shows a line of best fit to be coincidental for *M. columbi* and *M. exilis*, supporting the probable ancestral relationship of the mainland mammoth for the island form. Dental age assignments, on the relative, ‘African Elephant Year’ scale, imply high mortality rates in the ‘0-30 year’ range; few individuals survive past ‘50 years’ of age. Two individuals represent animals whose mandibular teeth were missing due to advanced age and wear, yet the animals continued to masticate against the jaw bone.

Chronology for pygmy mammoths has been one of the weakest points of Channel Islands paleontology. Published dates have been obtained from charcoal associated with mammoth remains. Wenner *et al.* (1991) have branded all such dates as ‘equivocal’ and suggest they should be discarded. In part, this is because it has been stated that all mammoth remains on the islands are secondarily deposited (Orr 1959, 1968; Cushing *et al.* 1986; Roth 1982, 1996; Wenner *et al.* 1991). They (Wenner *et al.* 1991) even go so far as to infer, “...there is no natural charcoal on the islands”.

The 1994 skeleton was sampled for bone from the marrow-producing segment of the right femur. The resulting accelerator-mass spectrometry (AMS) date for the animal was 12,840 +/- 410 yr BP (CAMS 24429). Not only was this date from mammoth bone itself, there was no question as to the remains being in primary deposition, as even the smallest bones of the phalanges were still in articular position. Since that time, other AMS dates on bone collagen have been obtained, as well as dates from associated charcoal. Some samples differ as little as 10 to 20 years between the bone date and the associated charcoal date. This tends to refute some of the claims made by Wenner *et al.* (1991).

Summarizing the available radiocarbon chronology of the Channel Island Mammoths, it appears they have been on the islands, in pygmy form, essentially unchanged, for more than 47,000 years (beyond the limits of radiocarbon chronology). It also appears that they may have survived until the early Holocene colonization of the islands by the ancestors of the ancient Chumash people, first recorded between 10,800 and 11,300 years ago.

REFERENCES

Agenbroad, L.D. 1994. Taxonomy of North American *Mammuthus columbi* and biometrics of the Hot Springs mammoths. In Agenbroad, L. D. and J. I. Mead (eds.), *The Hot Springs Mammoth Site: a decade of field and laboratory research in paleontology, geology, and paleontology*: 158-207. The Mammoth Site of Hot Springs, South Dakota, Inc. Hot Springs.

Agenbroad, L.D. 1998. New pygmy mammoth (*Mammuthus exilis*) localities and radiocarbon dates from San Miguel, Santa Rosa, and Santa Cruz Islands, California. In Weigand, P. (ed.), *Contributions to the geology of the Northern Channel Islands, Southern California*: 169-175. Bakersfield: Pacific Section of the American Association of Petroleum Geologists.

Agenbroad, L.D., Morris, D. & Roth., V.L. 1999. Pygmy mammoths (*M. exilis*) from Santa Rosa Island, Channel Islands National Park, California, USA. In Haynes, G., J. Klimowicz and W.F. Reumer (eds.), *Mammoths and the Mammoth Fauna: studies of an extinct ecosystem. Proceedings of the First International Mammoth Conference*. *Deinsea* 6: 89-102. St. Petersburg, Russia.

Cushing, J.E., Wenner, A.M., Noble, E. & Daly, M. 1986. A groundwater hypothesis for the origin of ‘fire areas’ on the Northern Channel Islands, California. *Quaternary Research* 26: 207-217.

Foster, J.B. 1964. Evolution of mammals on islands. *Nature* 202: 234-235.

Mol, D. 1995. Over dwergolifanten en dwergmammoeten. *Cranium* 12: 38-40.

Orr, P. 1956. Dwarf mammoths and man on Santa Rosa Island. *University of Utah Anthropological Papers* 26: 75-81.

Orr, P. 1968. *Prehistory of Santa Rosa Island.* Santa Barbara Museum of Natural History.

Roth, V.L. 1982. D*warf mammoth from the Santa Barbara, California Channel Islands: size, shape, development, and evolution.* Ph.D. dissertation. New Haven: Yale University.

Roth, V.L. 1996. Pleistocene dwarf elephants from the California Islands. In Shoshani, J. H. and P. Tassy (eds.), *The Proboscidea*: 249-253. Oxford: University of Oxford Press.

Sondaar, P.Y. 1977. Insularity and its effect on mammal evolution. In Hecht, M.K., P.C. Goody and B.M. Hecht (eds.), Major patterns in vertebrate evolution. *NATO Advanced Studies Institute Series* 14: 671-707.

Stearns, R.E.C. 1973. (brief note) *Proceedings of the California Academy of Sciences* 5: 152.

Stock, C. & Furlong, E.L. 1928. The Pleistocene elephants of Santa Rosa Island, California. *Science* LXVIII: 140-141.

Tikhonov, A. 1997. (brief note) Zoological Institute Russian Academy of Sciences, St. Petersburg, Russia. Department of History of Fauna. *Euromam Newsletter* 4: 14-15.

Wenner, A.M., Cushing, J., Noble, E. & Daly, M. 1991. Mammoth radiocarbon dates from the northern Channel Islands, California. *Proceedings of the Society for California Archaeology* 4: 1-6.

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Large-sized and middle-sized elephants from the Pleistocene of Sicily: the case of Contrada Fusco (Siracusa, Southeastern Sicily)

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SUMMARY: In Sicily, large-sized elephants have been found in association with the medium-sized species *Palaeoloxodon (=Elephas) mnaidriensis* in the so-called "stadio di Maccagnone" dating to the late Middle Pleistocene. The possibility that they represent a different species than *P. mnaidriensis* (for instance a subspecies of *P. antiquus*) is not unanimously accepted by scholars and an alternative hypothesis must be considered. The aim of this study is to explore new aspects of this subject starting from the excavation of Contrada Fusco. At this site large-sized and middle-sized elephants were found in the same stratigraphic levels dating to isotope stage 5. The large number of recovered remains provide us with a good basis from a statistical point of view. Preliminary biometric data seem to suggest that sexual dimorphism could be invoked to explain size differences for elephants in the faunal assemblage.

1. THE EXCAVATION OF CONTRADA FUSCO

The excavation of Contrada Fusco, close to the western periphery of Siracusa, took place from 1991 to the end of 1995. It uncovered a complex stratigraphic series which has furnished an enormous quantity of palaeontological and palaeoenvironmental data. The faunal assemblage includes 55 species of vertebrates, of which the following have been identified so far: fishes, reptiles. amphibians, birds, micromammals (insectivores and rodents), otters, hyenas, bears, and large sized mammals as hippopotamus and elephants.

The stratigraphic sequence starts with marine clays which date to the end of the Sicilian (Caruso 1996) and contain *Globorotalia truncatulinoides excelsa*, *Hyalinea baltica*, and *Gephyrocapsa* sp3. They are overlain by continental silts which contain no vertebrate remains (level L1). The top of this unit is incised by channels filled with alluvial sediments (related to a braided system) which are mainly gravels (level All) and contain abundant vertebrate remains. The faunal assemblage is dominated by a "medium sized" elephant, formerly called *Palaeoloxodon (=Elephas) mnaidriensis*, and a second kind of elephant of larger dimensions which has been provisionally classified as *Elephas* sp.

Pollen analyses (Arobba 1996) demonstrated the presence of a shrub vegetation while the few trees formed patches of woodland or grew in those places where it was possible to reach the uppermost water-table. Among the birds there is a prevalence of species typical of open environments, confirming that the climate must have been rather dry and substantially warm (Cassoli & Tagliacozzo 1996) with probable seasonal rainfall.

In the following phase a limited marine transgression deposited biogenic limestones (level C3) eastwards, while westwards there are sandy limestones and sands typical of a transitional beach environment (level C4). These latter sediments contain numerous vertebrate remains among which the hippopotamus becomes more and more frequent.

A subsequent regression led to the formation of a vast coastal plain characterised by ponds and marshes populated by a great variety of vertebrates. Dominated by the presence of the hippopotamus, this level (L2) shows a very low percentage of elephant remains. It is possible that the herds were disturbed by the large hippopotamus population and preferred to exploit other water resources rather than competing with them.

This phase ends with a new marine transgression which caused the formation of a huge salt water lagoon. The sediments (level L3) contain a few remains of hippopotamus and mark the end of the Middle Pleistocene deposits in the area.

The average age obtained using Electron Spin Resonance for the three levels (All, C4 and L2) which are rich in fauna is 146,800 ± 28,700 years BP, so within one standard deviation, and in view of the likely interglacial age of the deposits, the stratigraphic sequence can be referred to isotope stage 5 (Rhodes 1996). The faunal assemblage could be referred to the so called “stadio di Maccagnone” (Burgio 1997) characterised by a well balanced fauna with few endemic features.

The presence of large-sized elephants in the faunal assemblage is one of the most interesting features. Large sized elephants have previously been found in Sicily, for instance during the excavations in Viale Libertà in Palermo. These have been referred to *Palaeoloxodon (=Elephas) antiquus leonardii*, a subspecies of the continental *P. antiquus*. The faunal assemblage of Contrada Fusco is probably the largest sample available so far, thus it could furnish us a starting point for unravelling the significance of these larger individuals.

2. LARGE-SIZED VS. MIDDLE-SIZED INDIVIDUALS

If large- and medium-sized individuals represent two distinct species, the Contrada Fusco evidence shows that they were sympatric, but is this the only model that could explain their co-occurrence?

It is possible that the elephant population of Contrada Fusco represents a time averaged assemblage in which size differences could be explained as intraspecific patterns. For example genetic drift has been invoked by some scholars to explain the presence of large sized individuals – in this case ancestor-like features occasionally reappear in a population which shows a low degree of genetic modifications due to insularity (Malatesta 1985).

On the other hand it is possible that in a large faunal assemblage such as Contrada Fusco we could have only one sexually dimorphic species, with social patterns that are similar to those shown by living elephants, where adult males and females are segregated. The presence of some larger elephants in the faunal assemblage could indicate mixed herds involved in die-off events or even animals that did not live together but visited the area at different times. In fact, like modern male and female elephants, they could have lived apart most of the time, but with overlapping home ranges, using the same water resources so that they occasionally died in the same area. In this case, size differences in the Contrada Fusco assemblage would not be so dramatic in relation to modern populations. In Hwange National Park, Zimbabwe (Tab. 1) males are

Tab.1 - Humerus length for *Loxodonta africana* in Hwange National Park, Zimbabwe. Source: Haynes (1991).

Specimen	Sex	Humerus length (cm)
Makololo 2	M	111.0
Guvalala	M	108.0
Shabi Shabi (a)	F	85.0
Shabi Shabi (b)	F	88.0
Shabi Shabi (c)	F	83.0

Tab.2 - Humerus length for “large-sized” and “medium-sized” elephants in Contrada Fusco. Bone lengths indicated as incomplete are likely to only slightly underestimate the true value.

Specimen	Humerus length (cm)	Remarks
SR FSC B 4 – 1	103,15	
SR FSC O 21 – 1	>69	Lateral tuberosity missing
SR FSC ICL 16 – 1	>68,5	Lateral tuberosity missing
SR FSC ICO 26 – 1	65,8	Distal epiphysis fusion line still visible
SR FSC INW 25 – 1	>70	Lateral tuberosity damaged, distal epiphysis fusion line still visible

20-40% taller than females, humeri and femora being about 17-25% longer (in individuals over fifteen years old) (Haynes 1991). while differences in limb bones over 40% for *Loxodonta africana* were occasionally observed (Haynes pers. comm.),

Conversely in Contrada Fusco (Tab. 2) the “large-sized” humerus B4–1 is less than 35 % longer than “medium-sized” humeri with complete or almost complete epiphyseal fusion (stage 4 and 5, see Haynes 1991).

Even though the study of the Contrada Fusco assemblage is still in progress, the “large sized” vs. “medium-sized” ratio is consistent with data obtained from modern populations, if the large bones represent males at the upper end of their normal size distribution; in fact “large sized bones” represent less than 5% of the elephant bones recovered from Contrada Fusco.

3. CONCLUSIONS

The possibility that the large sized elephants of the “stadio di Maccagnone” did not represent a different species from medium-sized elephants must be considered. Biometric and morphologic data concerning large sized individuals are scarce and not statistically significant. Whether they represent ancestor-like individuals according to a genetic drift model, or just big adult males in the sexual dimorphism model, a revision of the available data is needed. The Contrada Fusco assemblage could be a good starting point to compare distinctive features of large and middle sized insular elephants and their continental and modern relatives.

4. REFERENCES

Arobba, D. 1996. Indagini palinologiche. In Basile B. & Chilardi S. (eds.), *Siracusa, le ossa dei giganti. Lo scavo paleontologico di Contrada Fusco*: 45-53. Siracusa, Palermo: Arnaldo Lombardi.

Burgio, E. 1997. Le attuali conoscenze sui mammiferi terrestri quaternari della Sicilia. In S. Tusa (ed.), *Prima Sicilia, alle origini della società siciliana*: 54-71. Palermo: Ediprint.

Caruso, A. 1996. Le associazioni microfaunistiche a foraminiferi e nannofossili calcarei. In Basile B. & Chilardi S. (eds.), S*iracusa, le ossa dei giganti. Lo scavo paleontologico di Contrada Fusco*: 35-38. Siracusa, Palermo: Arnaldo Lombardi.

Cassoli, P.F. & Tagliacozzo, A. 1996. L’avifauna. In Basile B. & Chilardi S. (eds.), *Siracusa, le ossa dei giganti. Lo scavo paleontologico di Contrada Fusco, catalogo della mostra*: 61-67. Siracusa, Palermo: Arnaldo Lombardi.

Haynes, G. 1991. *Mammoths, Mastodonts and Elephants. Biology, behavior and the fossil record*. Cambridge: Cambridge University Press.

Malatesta, A. 1985. *Geologia e Paleobiologia dell’età glaciale*. Firenze: Nuova Italia Scientifica.

Rhodes, E.J. 1996. ESR dating on tooth enamel. In Basile B. & Chilardi S. (eds.), *Siracusa, le ossa dei giganti. Lo scavo paleontologico di Contrada Fusco*: 39-44. Siracusa, Palermo: Arnaldo Lombardi.

Palaeoloxodon cypriotes, the dwarf elephant of Cyprus: size and scaling comparisons with *P. falconeri* (Sicily-Malta) and mainland *P. antiquus*

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SUMMARY: We provide the first detailed biometric study of *Palaeoloxodon cypriotes*, the dwarf elephant of Cyprus, based on the Bate collection from Imbohary. Molar morphology indicates derivation from *P. antiquus*, while molar proportions are unchanged from that species, paradoxically implying an allometric shift. To maintain function, enamel is relatively thick and plates have been lost, producing a molar lamellar frequency analogous to *P. antiquus* milk molars of the same size. Body size was similar to or slightly larger than *P. falconeri*, but the teeth were even smaller. Perhaps as a result, plate loss was more extreme than in that species. Sparse material of slightly larger dwarf elephants from Achna are of uncertain status.

The dwarf elephants of Cyprus were first described by Bate (1904), but have been little-studied since that time. The Bate collection in the Natural History Museum, London, formed the basis of our study. Elephant remains comprise 44 dwarf molars from Imbohary, in the north of the country west of Nicosia, and seven larger (but still dwarf) molars from Achna in the south-east of the country. Very sparse post-cranial and tusk material was also examined.

The molars strongly support derivation from *P. antiquus*, the mainland straight-tusked elephant. They share features such as median expansions of the enamel loops; the division of the loop in early wear into a long central portion flanked by small rings on each side; the tight folding of the enamel; and the narrow shape of the crown.

The single measurable long bone of *P. cypriotes* in the Bate collection – a femur – provides an estimated body weight – using the scaling formula derived by Roth (1990) – of approximately 200 kg. This represents a weight reduction of 98% from the 10-tonne ancestor. A single preserved tusk shows a degree of curvature greater than that seen in *P. antiquus*.

Molars are reduced to approximately 40% the linear size of mainland *P. antiquus*. Remarkably, given the extreme degree of dwarfing, the length/width/height proportions, i.e. the gross shape of the tooth, are indistinguishable from those of *P. antiquus*. Clearly any changes in skull morphology (e.g. the paedomorphic effects found in *P. falconeri*: Palombo, this volume) have not impinged on molar shape, including crown height. In retaining the same shape as the ancestral *P. antiquus*, the dwarf teeth in fact depart from the intraspecific allometric trend within that species. This suggests that natural selection may have been required to maintain the same (presumably optimal) shape.

Other features have changed, however: molar enamel is thicker, relative to the size of the tooth, than in *P. antiquus*, and plate number has decreased. Both of these, presumably, help maintain shearing function in the much smaller tooth: isometrically reduced enamel might be too thin for mechanical function or even stability, and plates are lost to retain optimal separation between them (cf. Maglio 1973, Lister & Joysey 1992, Lister 1996). In third molars, mean plate number has dropped from c. 18 to c. 11, representing a 40% loss, while in earlier tooth generations between one and three plates have been lost. A very interesting finding is that

P. cypriotes molars (e.g. M3) have exactly the same lamellar frequency as earlier *P. antiquus* tooth generations (e.g. dP3, dP4) of the same crown width. In other words, plates have been lost to just the degree that maintains optimal function for a tooth of that size.

Although limited by small sample sizes, an interesting comparison can be made between *P. cypriotes* and *P. falconeri* from Malta and Sicily. The individual represented by the Imbohary femur was above the range for Sicilan *P. falconeri* based on limb-bone dimensions given by Ambrosetti (1968), suggesting a somewhat larger body size. On the other hand, the molar teeth are clearly smaller in the Cypriot animal, by as much as 40% in mean M3 lengths. Relative to *P. antiquus*, *P. cypriotes* has a tooth: body ratio closer to isometry, whereas *P. falconeri* shows more strongly the commonly observed relatively larger teeth of dwarfed forms (Ambrosetti 1968; Lister 1996). The reduction in plate number is relatively modest in *P. falconeri* (typically 15 plates remain in M3) compared to *P. cypriotes*. This may indicate that the functional need to shed plates accelerates as the tooth becomes progressively smaller. Alternatively, the degree of plate reduction, as well as the tooth: body size ratio, might reflect greater genetic entrenchment of the dwarfing process in *P. cypriotes* than in *P. falconeri* (cf. Lister 1995).

Finally, the remains from Achna, of unknown age, are too sparse and fragmentary to allow detailed analysis, but indicate a dwarf palaeoloxodont elephant probably about 10-20% larger in dental dimensions than *P. cypriotes.* The work of Simmons (1999) and colleagues at the Akrotiri Aetokremnos locality demonstrates survival of *P. cypriotes* until at least 11 ka BP. Given this very late age, it is tempting to suppose that the Achna population is older and its antecedent. However, until more material becomes available, including an estimate of the age of the larger form, it is impossible to say whether are dealing with two points of a single evolving lineage, or separate dwarfing events, nor whether a taxonomic separation is justified.

In conclusion, the independent dwarfing of *Palaeoloxodon antiquus* on several Mediterranean islands provides an exciting experiment for testing evolutionary patterns and processes. The comparison here between *P. cypriotes* and *P. falconeri* is a small beginning of such a study. In the case of *P. cypriotes*, the analysis of new material from Akrotiri Aetokremnos should provide further data contributing to its fuller characterisation.

References

Ambrosetti, P. 1968. The Pleistocene dwarf elephants of Spinagallo (Siracusa, south-eastern Sicily). *Geolologica Romana*, 7: 277-398.

Bate, D.M.A. 1904. Further note on the remains of *Elephas cypriotes* from a cave-deposit in Cyprus. *Phil. Trans. R. Soc. Lond. B*, 197: 347-360.

Lister, A.M. 1995. Sea levels and the evolution of island endemics: the dwarf red deer of Jrsey. *Geological Society Special Publications*, 96: 151-172.

Lister, A.M. 1996. Dwarfing in island elephants and deer: processes in relation to time of isolation. *Symp. zool. Soc. Lond.*, 69: 277-292.

Lister, A.M. & Joysey, K.A. 1992. Scaling effects in elephant dental evolution - the example of Eurasian *Mammuthus*. In P. Smith & E. Tchernov (eds.) *Structure, Function and Evolution of Teeth*: 185-213. Jerusalem: Freund.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.*, 63: 1-149.

Palombo, M.R. 2001. Paedomorphic features and allometric growth in the skull of *Elephas falconeri* from Spinagallo (Middle Pleistocene, Sicily). *This volume*.

Roth, V.L. 1990. Insular dwarf elephants: a case study in body mass estimation and ecological inference. J. In Damuth, & B.J. Mac Fadden, (eds.) *Body Size in Mammalian Paleobiology: Estimation and Biological Implications*: 151-179. Cambridge: Cambridge University Press.

Simmons, A.H. 1999. *Faunal Extinction in an Island Society: Pygmy Hippopotamus Hunters of Cyprus*. Plenum.

Mammuthus lamarmorae (Major, 1883) remains in the pre-Tyrrhenian deposits of San Giovanni in Sinis (Western Sardinia, Italy)

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SUMMARY: Scanty remains of endemic elephants have been recorded in the Late Pleistocene deposits of Sardinia. The stratigraphic position and paleoenvironmental setting of the molar from San Giovanni in Sinis is discussed in some detail, and a full description of the fossil is given, allowing discussion of some hypotheses about the mainland ancestor and the time of the colonisation of the island

1. INTRODUCTION

Fossil remains of endemic elephants have been collected from the Pleistocene deposits of several Mediterranean islands. They have been generally considered as paleoloxodontine, derived from the continental Middle and Late Pleistocene *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley. The only apparent exception is the middle-sized *Mammuthus lamarmorae* (Major) of Sardinia. Some tarsal, carpal and long bones, from Last Glacial aeolian deposits outcropping at Fontana Morimenta (Gonnesa), were first reported by Acconci (1881). Following this discovery, Major (1883) described the new species "*Elephas lamarmorae*", but did not illustrate it. During the second half of the 20th Century, two further molars were discovered: one in post-Tyrrhenian (post-OI stage 5) breccias at Tramariglio (Alghero) (Malatesta 1954), and the other in pre-Tyrrhenian (pre-OI stage 5) continental deposits at S. Giovanni in Sinis (Ambrosetti 1972). The latter is the only specimen for which stratigraphic control is available. We present here in some detail both the morphological characters and the local stratigraphic sequence.

2. GEOLOGICAL SETTING

At the southern tip of the Sinis peninsula, on the western coast of Sardinia, marine and continental deposits of late Middle Pleistocene age outcrop near the village of San Giovanni (Fig. 1). Because of marine erosion, they are found over c. 1 km in a quickly retreating cliff. Roman tombs, cut into the consolidated deposits, can be spotted in huge collapsed blocks, washed by the sea. The stratigraphy is made complex by frequent lateral changes and several papers have been devoted to its interpretation (Maxia & Pecorini 1968; Ambrosetti 1972; Caloi *et al.* 1980; Ulzega *et al.* 1980; Ulzega & Ozer 1982; Ulzega & Hearty 1986; Carboni & Lecca 1985; Dudaud *et al.* 1991;

Kindler *et al.* 1997).

The deposits that we examined are located in the village itself, next to the Roman tombs. This is where the elephant tooth, studied by Maxia and Pecorini (1968), and by Ambrosetti (1972), was discovered at sea level. They include three different sequences.

2.1 San Giovanni in Sinis section (Fig. 2).

Sequence A, at the base of the outcrop, is characterised by calcrete in which the elephant molar was discovered. It is overlain by a pedogenised sandy deposit rich in remains of Helicidae and bioclastic fragments (benthic foraminifers, echinoids and red algae).

Sequence A, truncated by an erosional surface (S1) sloping towards the southeast, is overlapped by sequence B, comprising polygenic conglomerate, with fragments reworked from an eroded underlying level, and including basalt pebbles. This conglomerate is capped by beach sands showing low-angle cross-bedding, in the upper part of which is developed a palaeosol with rhyzoliths. This palaeosol is overlain by a calcarenite with tightly packed *Mytilus* and *Ostrea* shells, and then by lagoonal deposits with *Limnea* – with development of calcrete. An erosional surface (S2) marks the base of sequence C, which starts with a thin conglomerate including fragments from an eroded underlying level with *Mytilus*, followed by beach sand deposits, with low-angle cross-bedding, including some remains of *Megaceroides cazioti* (Dépéret) at the bottom. Sequence C ends with cross-bedded dune deposits. Ulzega and Hearty (1986) proposed an age of 90 ±15 ka (OI substage 5c) for the deposit with *Mytilus* in Sequence B, based on an A/I ratio on a *Glycymeris* shell of 0.32 . Accordingly, they dated sequence A deposits to OI substage 5e. Davaud *et al.* (1991) and Kindler *et al.* (1997) hypothesised that sequence A deposits could be earlier than OI substage 5e, i.e. actually pre-date the last interglacial period.

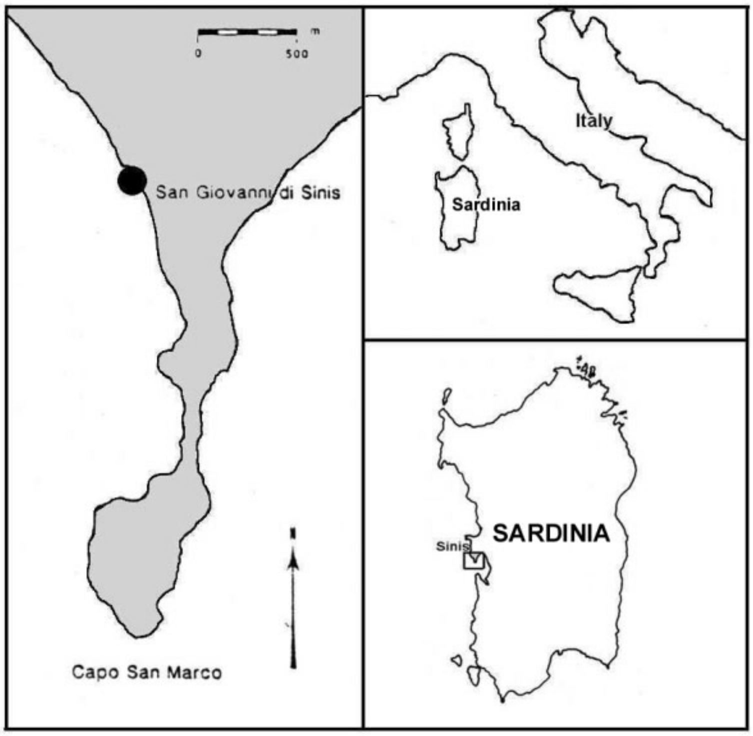

Fig.1 - Location of the S. Giovanni section.

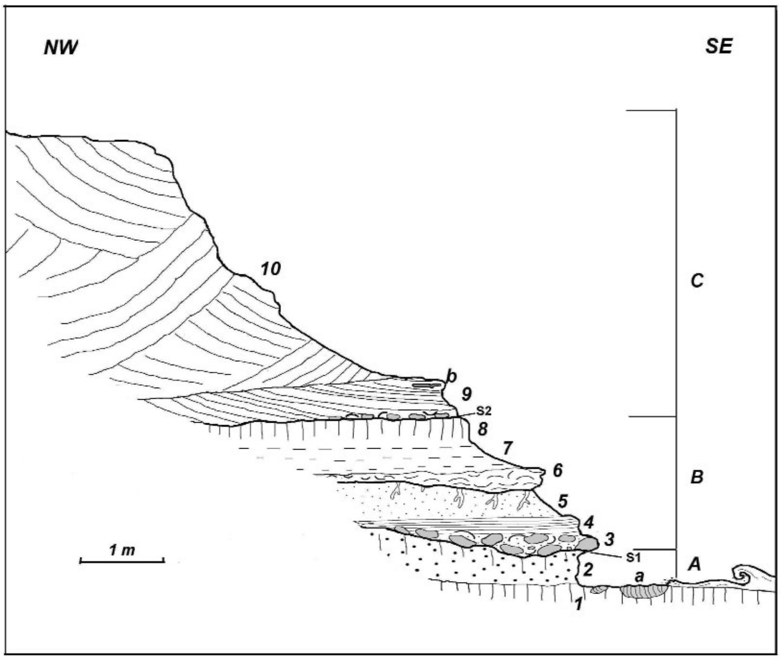

Fig.2 - San Giovanni section. 1: calcrete; 2: palaeosol developed on beach sediments rich in Helicodae remains; 3 conglomerate containing pebbles from the erosion of the underlying level as well as basalt pebbles; 4: beach sediments; 5: palaesols with rhizoliths; 6: marine deposits rich in *Mytilus* and *Ostrea* shells (OI substage 5e); 7: lagoonal deposits with *Limnea*; 8: calcrete; 9: beach deposits, overlying a conglomerate with remains of *Ostrea* shells; 10: dunes; a: Elephant molar; b: cervid remains; S1 and S2 erosional surfaces. A, B, C: sequences.

3. *MAMMUTHUS LAMARMORAE* (MAJOR, 1883)

In the Sixties, as mentioned above, scanty dental remains of a small-sized elephant were discovered by Prof. Giuseppe Pecorini in sediments outcropping at San Giovanni in Sinis. The most important of these remains is a well preserved upper molar, with only the roots missing, now at the Dipartimento di Scienze della Terra of the University of Cagliari. The molar was described by Ambrosetti (1972), who considered it an M^3. Indeed, there is no clear evidence of pressure by a posterior tooth, so it could be a last molar even if the gradually reducing height, typical of an elephantid M^3, is not evident. The tooth is almost completely in wear: of the 11 laminae, 9 are in use, and the anterior half of the first lamina, worn down to the root, is lost. The short, wide shape of the tooth suggests the loss by wear of some other laminae at the front. However, the three very worn anterior plates are nearly fused to each other, and apparently belong to the same root. Consequently the hypothesis that the molar could be complete cannot be ruled out. With the exception of the almost unworn 9th, all the laminae of the occlusal surface show a complete, undulating enamel loop. Additional lingual and buccal conules, very reduced, are present at the posterior side of the 4th and 5th lamina. The laminae are quite well packed even near the top of the crown, and the enamel is rather thick; the enamel loops are regularly plicated; and the folds, extending to the lateral and medial faces of the laminae, are more tightly packed near the root.

The morphological and biometrical characters of the molar, with a more-or-less oval shaped occlusal surface, undulated enamel plates, and regularly folded enamel loops, as well as the enamel thickness and average lamellar frequency, all suggest an attribution to the genus *Mammuthus*.

Tab.1 - Measurements of *M. lamarmorae* M^3 from San Giovanni in Sinis.

Measurements of *M. lamarmorae* M^3 from San Giovanni in Sinis
Plate formula = ?10 _ + posterior talon; number of functional laminae = 8 _; greatest mesio-distal length =130 mm, functional (occlusal) length = 116 mm, greatest bucco-lingual breadth = 69 mm; functional (occlusal) breadth = 55 mm; height = 90+ mm; average lamellar frequency = 8; enamel thickness = 1,8; hypsodonty index = 1,55 (minimal value); functional lamellar index (functional laminae/functional length X 100) = 7,33

According to current evidence, the molars of endemic elephants are characterised by less advanced features when compared to their mainland ancestors, especially so when taking into account the size reduction, which would produce, among other things, an increased lamellar frequency (Lister & Joysey 1992).

All things considered, according to enamel thickness, lamellar frequency and enamel loop morphology it seem more probable that the ancestor of *M. lamarmorae* from San Giovanni in Sinis was *Mammuthus trogontheri* (Pohlig) rather than *Mammuthus meridionalis* (Nesti). Nevertheless, due to the scarcity of remains, this hypothesis still has to be fully substantiated.

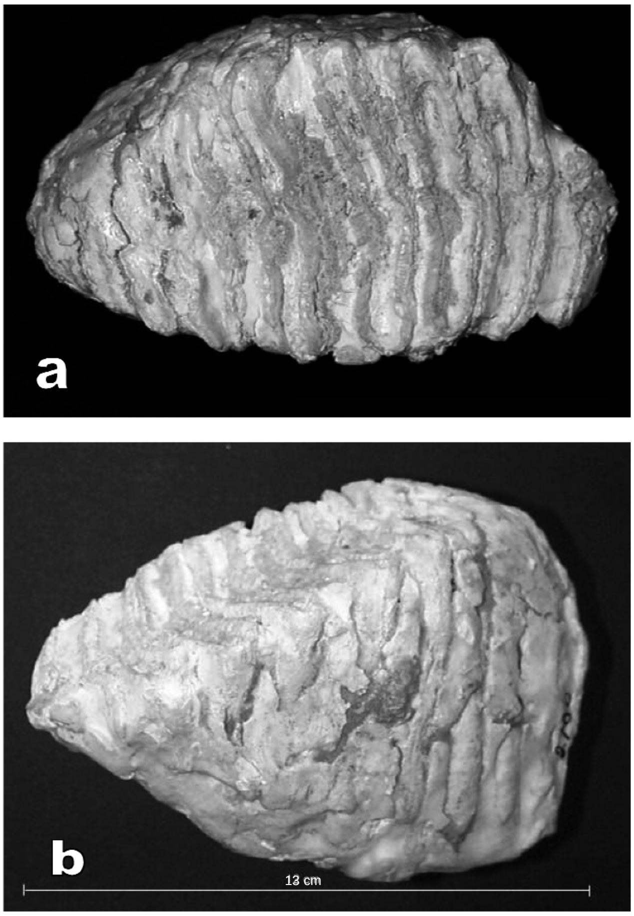

Fig.3 - *Mammuthus lamarmorae* (Major, 1883) from San Giovanni in Sinis: M^3 in occlusal view, approximately x0.7 of natural size.

4. FINAL REMARKS

The study of the stratigraphic section of San Giovanni confirms that, as already suggested by previous studies, the layer in which the elephant molar was found occurs in sequence A (Fig. 2). According to Davaud *et al.* (1991) and Kindler *et al.* (1997) the deposits of sequence A could be assigned to the pre-Tyrrhenian age (pre-OI stage 5).

The deposition of the remains probably occurred within sandy beach sediments, subsequently affected by pedogenesis while the sea level was falling. A calcrete then developed during an arid climatic phase with low rainfall. An erosive phase followed, related to increased rainfall, and this eventually truncated the soil overlying the calcrete. A marine transgression and deposition of Tyrrhenian (OI stage 5) sediments followed this erosive phase.

Since elephant remains have not been recorded from earlier deposits in Sardinia, and even if other hypotheses cannot be ruled out, it seems likely that the ancestors colonised the island during the late Middle Pleistocene.

5. ACKNOWLEDGEMENTS

We are indebted to Prof. Giuseppe Pecorini, who most kindly accompanied us to the spot where he made his discovery at S. Giovanni in Sinis, and generously shared with us the observations he made at the time of the discovery, allowing comparisons with the currently available stratigraphic sequence. We want to thank Dr. Lister for his useful comments and suggestions to the text.

Drs. C. Cappai, P. Casarella, and R. Deplano (Museo di Paleontologia, Dipartimento di Scienze della Terra, Università di Cagliari) made available good quality pictures of the fossil tooth.

6. REFERENCES

Acconci, L. 1881. Sopra alcune ossa fossili di Elefante rinvenute nel Quaternario della zona di Marimenta in Sardegna. *Proc. Verb. Atti Soc. Tosc. Sc. Nat.* 2: 266-267

Ambrosetti, P. 1972. L'elefante fossile della Sardegna. *Bol. Soc. Geol. Ital.* 91: 127-13.

Caloi, L., Katsakis, T., Palombo, M.R., Petronio, C. 1980. Il giacimento a vertebrati del Pleistocene superiore di San Giovanni in Sinis (Sardegna occidentale). *Rend. Sci. Fis. Mat. Nat. Lincei* 69: 185-197.

Carboni, S. & Lecca, L. 1985. Osservazioni sul Pleistocene medio-superiore della penisola del Sinis Sardegna Occidentale. *Bol. Soc. Geol. Ital.* 104: 459-477.

Duvaud, E., Kindler, P., Martini, R., Strasser, A. 1991. Enregistrement des variations eustatiques dans des littoraux du Pleistocène superieur San Giovanni di Sinis (Sardegna occidentale). *Bull. Soc. Géol. Fr.* 162: 523-533.

Kindler, P., Duvaud, E., Strasser, A. 1997. Tyrrhenian coastal deposits from Sardinia (Italy): a petrographic record of high sea levels and shifting climate belts during the last interglacial (isotopic substage 5e). *Palaeogeography, Palaeoclimatology, Palaeoecology* 133: 1-25.

Lister, A.M. & Joysey, K.A. 1992. Scaling effects in elephant dental evolution - the example of Eurasian *Mammuthus*. In Smith P. & Tchernov E. (eds.), *Structure, function and evolution of teeth*: 185-213. London & Tel Aviv: Freund Publishing House Ltd.

Malatesta, A. 1954. Primo dente di elefante fossile rinvenuto in Sardegna. *Quaternaria* I: 97-105.

Maxia, C. & Pecorini, G. 1968. *Il Quaternario della Sardegna. Atti X° Congresso Int. Studi Sardi*: 247-266.

Ulzega, A. & Hearty, P.J. 1986. Geomorphology, stratigraphy and geochronology of Late Quaternary marine deposits in Sardinia. *Z. Geomorphol. N.F., Suppl. Bd.* 62: 119-129.

Ulzega, A., Oser, A., Lecca, L., Leone, F., Pecorini, G., Spano, C., Cordy, J.M. 1980. *Excursion – Table ronde Tyrrhénien de Sardaigne. Guidebook*: 88 pp. INQUA, Univ. Cagliari.

Ulzega, A., Oser, A. 1982. *Comptes-rendus de l'Excursion- Table ronde Tyrrhénien de Sardaigne*: 110 p. INQUA, Univ. Cagliari, April 1980.

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Endemic elephants of the Mediterranean Islands: knowledge, problems and perspectives

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SUMMARY: Fossil remains of endemic elephants have been collected in Pleistocene deposits of several Mediterranean islands. Colonisation phases were generally followed on each island or group of islands by dwarfing processes that apparently allowed the parallel evolution of taxa exhibiting similar size reduction and similar morphological features. In some cases, as in Crete, the faunal biochronological setting allows us to recognise the taxa resulting from each migration phase. In other cases, as in Sicily and Malta, the time of colonisation, the phylogenetic relationships, and the taxonomic status of some specimens are doubtful. This paper summarises present knowledge and highlights the major unresolved problems.

1. INTRODUCTION

Elephants were the most characteristic and common taxa in Pleistocene unbalanced endemic island faunas. In the Mediterranean, their remains have been known since the 19th century in the islands of both the western (Sardinia, Sicily, Malta and the Egad Islands) and eastern (Crete, Cyclades, Dodecanese, Cyprus) basins (Caloi *et al.* 1996 and references within). Mediterranean insular elephants have generally been considered as paleoloxodontine, derived from the Middle and Late Pleistocene continental *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley 1847. The only exception is the small Sardinian *Mammuthus lamarmorae* (Major 1883), descendent of an representative of the genus *Mammuthus* (*?M. trogontherii*), while the phylogenetic relationships of *“Elephas” cypriotes* Bate, 1907 and *“Elephas chaniensis”* Symeonidis, 2000 are uncertain.

Dwarfed elephant populations evolved independently on each island. Consequently, the endemic species of elephant, which inhabited the Mediterranean insular area during the Pleistocene, were taxonomically different in each island or group of very close islands (e.g. the Cyclades archipelagos).

Nevertheless, in comparison with their mainland ancestor, endemic elephants were characterised by similar evolutionary patterns that allowed parallel size reduction and, eventually, the appearance of homoplastic characters. Accordingly, the populations of different islands (even when represented by scanty remains) are characterised by common features such as size reduction, relative increase in brain size, scanty or absent cranial bone pneumanisation, decrease in the number of molar laminae and increase in enamel thickness relative to the size of the tooth, reduction of graviportal structure of limbs, and greater morphological variability. The latter may be associated, at least in part, with an increased morphological and dimensional gap between the two sexes.

2. WESTERN MEDITERRANEAN

2.1 Sicily and Malta

In the Pleistocene mammal faunas of Malta, dwarf elephants have been known since the second half of the 19th century. In 1862, Falconer first presented to the British Association at Cambridge the description of the small elephants found in Malta, concluding that there was probably a phylogenetic relationship between the dwarf species and *"Elephas africanus"* Blumenbach, 1797. On this occasion, Falconer also proposed the name *Elephas melitensis* Falconer, 1868 for the new species. Falconer's notes were published in 1868. In 1867 Busk had proposed the new species *Elephas falconeri* for many of the smallest molars selected from the material originally ascribed by Falconer to *Elephas melitensis.*

The endemic elephants of Malta and Sicily were considered for decades as representatives of a progressive size reduction trend, begun by the mainland species *Elephas (Palaeoloxodon) antiquus*. According to this historical hypothesis, the first step of this process was the Sicilian relatively large-sized *Elephas antiquus leonardii* Aguirre, 1969, recorded from Middle Pleistocene deposits at Via Libertà (Palermo) (Aguirre 1969). The second step was represented by the middle-sized Sicilian and Maltese specimens of the group *Elephas mnaidriensis* (Adams 1874); the third by the medium-small-sized *"Elephas melitensis"* (considered by some authors a younger synonym of *Elephas mnaidriensis*); and the last by the smallest species *Elephas falconeri.*

However, stratigraphic (Burgio 1997; Burgio & Cani 1988) and geochemical (Bada *et al.* 1991) data demonstrated that the Sicilian medium-sized elephants of the *Elephas mnaidriensis* group are actually more recent than the smaller *Elephas falconeri*.

Sicilian endemic elephants belong to three distinct faunal complexes: *E. falconeri* FC (?Early Middle Pleistocene) characterized by an unbalanced, low diversity and strongly endemic fauna; *E. mnaidriensis* FC (late Middle- early Late Pleistocene) with a mixed, impoverished fauna including both endemic and continental taxa, and Contrada Pianetti FC (?early last Glacial) (Bonfiglio *et al.* 1997), represented by a local fauna characterised by the only known co-occurrence of *E. mnaidriensis, Equus hydruntinus* and other continental taxa, typical of the latest Pleistocene balanced fauna of Sicily.

As already hypothesised by some authors (e.g. Bonfiglio *et al.* 1997; Burgio & Cani 1988; Caloi *et al.* 1996; Palombo 1986), more that one mainland elephant species might have reached Sicily during several migration waves. The first wave could have taken place at the Early Pleistocene/Middle Pleistocene boundary, when the low sea level, related to cold phases (OIS 24-22-?20), reduced the distance between island and mainland coastlines. A second set of migration waves supposedly took place during the low sea level stand correlated with the stadial oscillations of the late Middle Pleistocene (OIS 10, 8 and 6). These phases involved several mammalian taxa, including some with limited swimming ability. Nevertheless various questions are still open.

Some specimens of intermediate size between *Elephas mnaidriensis* and *Elephas falconeri* have been found in Sicily associated with the smallest elephant specimens (Bonfiglio & Insacco 1992 and unpublished data, from Spinagallo cave and south-west Sicily,), as well as in levels underlying those with *Elephas falconeri* (Lupparello: Imbesi 1956). Some others have been recorded from latest Pleistocene deposits at Favignana, a minor island then connected to Sicily (Capasso Barbato *et al.* 1989). On the basis of available data, the hypothesis of two different populations of "intermediate"-sized elephants cannot be ruled out. The earlier one, of Middle Pleistocene age, might have given rise in Sicily to *Elephas falconeri*; the later, endemic one of Favignana, might have originated with the immigration of *Elephas mnaidriensis* to the islet. The taxonomic status of these specimens is still indeterminate.

Large-sized specimens have also been found in conglomerates of the "Messina Formation" (Bonfiglio & Berdar 1979), as well as at Contrada Fusco (Siracusa) (Chilardi, this volume). Moreover, recent discoveries in eastern Sicily suggest the occurrence of three forms of different sizes (Bonfiglio & Burgio 1990). Nevertheless, according to Chilardi's data (Chilardi, this volume) the elephant population of Contrada Fusco might represent a long-term time-averaged assemblage, in which size differences could be explained by intraspecific and sex-related patterns. “The presence of some larger elephants in the faunal assemblage possibly points to mixed herds involved in die-off events or even to animals that did not live together but visited the area at different times”. This hypothesis has yet to be substantiated.

Consequently the main open questions are: how many elephant taxa inhabited Malta, Sicily and the neighbouring islands? What were the relationships among these island populations? To what extent did the Early Pleistocene fragmentation of Sicily influence elephant evolution? How much did the close proximity of the mainland allow for migrations and genetic flow? Can hypotheses suggesting adaptive radiation be put forward? These problems are also the consequence of a lack of detailed knowledge of stratigraphical/biochronological relationships among some Maltese deposits, and of scarcity of data concerning the morphological and dimensional range of each elephant population. Everything considered, it is impossible to accept *sic et simpliciter* the current specific designations of Sicilian and Maltese elephant taxa.

2.2 Sardinia

Mammuthus lamarmorae (Major 1883) is the only endemic elephant of the Mediterranean islands belonging to the mammoth line. It is represented by some tarsal, carpal and long bones, from last glacial eolian deposits outcropping at Fontana Morimento (Gonnesa) (Acconci 1881). More recently, two molars, whose morphology is more closely related to *Mammuthus* than to *Palaeloxodon*, have been discovered in post-Tyrrhenian breccias at Tramariglio (Alghero) and in Pre-Tyrrhenian levels at S. Giovanni in Sinis (Melis *et al.* 2001). Elephant remains are not recorded, so far, from earlier deposits. Even if other hypotheses cannot be ruled out, we suggest that that the ancestor of *M. lamarmorae* reached Sardinia during the late Middle Pleistocene.

3. EASTERN MEDITERRANEAN

3.1 Crete

In Crete, endemic elephants were first mentioned by Bate (1905, 1907), who erected the new species *Elephas creticus* Bate, 1907, on the basis of the very small specimens of Maleka Cape. Moreover, Bate (1905) also recorded some remains from Kharoumbes, which were similar in size to the continental species *Elephas antiquus*. A third taxon, intermediate in size, was discovered at Grida Aviaki, and ascribed to *Elephas priscus* by Simonelli (1908). The occurrence of a middle-sized elephant has been confirmed by some remains from Kalo Chorafi, on which Kuss (1965) erected the new species “*Loxodonta” creutzburgi* (recte *Elephas creutzburgi*). Over time, several hypotheses have been put forward on the number and taxonomic status of the endemic elephants of Crete. On the basis of the previously available evidence, two elephantine species occurred on Crete, resulting from two distinct immigration phases and evolutionary processes. The earlier was *E. creticus*, found in association with *Kritimys kiridus* (Bate) and Early Pleistocene or early Middle Pleistocene in age. The later species, of Late Pleistocene age, was *E. creutzburgi*, discovered at Simonelli cave and in many other caves in association with *Mus minotaurus*.

A new species, *“Elephas” chaniensis,* was proposed recently for scanty remains, little reduced in size, found in submerged latest Pleistocene deposits in Kamos cave (Symeonides *et al.* 2001). According to these authors’ opinion, continental “elephants were roaming the Chania area during the last climatic minimum, 18,000 yr BP”. The phylogenetic relationship of this taxon is doubtful, in view of the lack of paleoloxodontine records in the Latest Pleistocene deposits of Greece.

3.2 Cyclades Islands

Remains of elephants probably belonging to the paleoloxodontine line, have been reported from the islands of Delos, Naxos, Kythnos, Serifos and Milos. The remains from the three latter islands have not been described. The specimens of different islands exhibit very different sizes: e.g. the Naxos elephant is of similar size to *E. melitensis*, while the Delos molar (Vaufrey 1929) falls within the range of a small *E. antiquus*. This is consistent with the paleogeography of Delos and a neighbouring island, which remained connected to Eubea during most the Pleistocene.

3.3 Dodecanese Islands

Some long bones belonging to an endemic elephant similar in size to *Elephas mnaidriensis* were found in Late Pleistocene cave deposits on Rhodos island (Symeonidis *et al.* 1974), while many more remains, belonging to a more dwarfed species, were discovered in Charcadio cave on Tilos island. The endemic elephants from Tilos have been considered as two different taxa by Bachermayer *et al.* (1976) because of the occurrence of two distinct dimensional groups, falling respectively in the *E. mnaidriensis* and *E. falconeri* size ranges. Following Theodorou (1983, 1988) "*the two groups indicate sexual dimorphism and have no stratigraphic significance*". This author had previously named the taxon "*Palaeoloxodon antiquus falconeri* Busk".

Actually, the Tilos elephant clearly represents an independent endemic species, perhaps belonging to a palaeoloxodontine line, as also indicated by the width of the Schreger angle of enamel microfibres, which excludes any relationship with the genus *Mammuthus*. According to the available stratigraphic data, and taking into consideration the lack of elephants in earlier deposits with deer remains, the continental ancestor possibly reached the island during negative eustatic oscillations at the beginning of the last glacial, and was the latest paleoloxodontine to survive in Europe.

3.4 Cyprus

Some remains of a very small elephant, as small as *E. falconeri*, found at a few sites on Cyprus, have been described as *Elephas cypriotes* Bate, 1903. Moreover, two molars belonging to a larger elephant have been recorded from Achna (Boekschoten & Sondaar 1972). The relationships between the smaller elephant and the Achna specimens cannot be defined due to the lack of any chronological data. From theavailable information, any picture of hypothetical colonisation phases, phylogenetic relationships, and the evolutionary patterns of the endemic Cypriot elephants are still unclear. See Davies & Lister, this volume.

4. CONCLUDING REMARKS

With the possible exception of *M. lamarmorae* of Sardinia, all the endemic Mediterranean elephants probably originated from the same continental taxon, i.e. *Elephas (Palaeoloxodon) antiquus*. This species again and again colonised the Aegean and Western Mediterranean islands, giving rise, sometimes on the same island, to several species (or subspecies) of different body sizes.

Consequently, different taxa, all descendants of the same ancestor, inhabited different islands (or the same island at a different time). There is no direct relationship among taxa from widely separated islands. Instead, a parallel evolutionary process allowed similar, more or less advanced, size reduction patterns and morpho-functional adaptive changes. The taxonomic status and the phylogenetic relationships of some endemic elephants (most notably the Sicilian an Maltese ones) are not clear. A systematic revision and a substantial improvement of stratigraphical and biochronological knowledge are necessary to understand the complex picture of the colonisation of Mediterranean islands by elephants.

Solving standing taxonomic problems will allow us to test different models of speciation and size reduction, on the basis of the evaluation of different factors: island size and physiography, climate and microclimate, distance from the coast, length of isolation, number and type of immigrant taxa, pre-existing taxa, extinction rates, and so on.

5. REFERENCES

Acconci, L. 1881. Sopra alcune ossa fossili di Elefante rinvenute nel Quaternario della zona di Marimenta in Sardegna. *Proc. Verb. Atti Soc. Tosc. Sc. Nat.*, 2: 266-267.

Aguirre, E.E. 1969. Revision sistématica de los Elephantidae por su morfologia y morfometria dentaria. *Estudios Geologicos*, 25: 317-367.

Bachmayer, Von F., Symeonidis, N., Seeman, R., Zapfe, H. 1976. Die ausgrabungen in der Zwergelefantenhohle "Charkadio" auf der Insel Tilos (Dodekanes, Griechenland) in der Jahren 1974 und 1975. *Ann. Naturhistor. Mus. Wien.*, 80: 113-144.

Bada, J.L., Belluomini, G., Bonfiglio, L., Branca, M., Burgio, E. & Delitala, L.M. 1991. Isoleucine epimerization ages of Quaternary mammals from Sicily. *Il Quaternario*, 4 (1a): 49-54.

Bate, D.M.A. 1905. Four and half months in Crete in searh of Pleistocene mammalian remains. *Geological Magazine*, 2: 193-202.

Bate, D.M.A. 1907. On Elephant Remains from Crete, with Description of Elephas creticus sp.n. *Proc. zool. Soc. London*: 238-250.

Boekschoten, G.J. & Sondaar, P.Y. 1972. On the fossil Mammalia of Cyprus. I-II *Proc. Konin. Neder. Ak. Wetensh.*, 75: 306-338.

Bonfiglio, L. & Berdar, A. 1979. Gli elefanti delle ghiaie pleistoceniche di Messina. *Quaternaria*, 21: 139-177.

Bonfiglio, L. & Burgio, E. 1990. New stratigraphic and paleocological data on mammal-bearing deposits of Sicily. *Abstracts IX Congr. Reg. Comm. Mediterranean Neogene Strat, Barcelona*: 32.

Bonfiglio, L., Insacco, G. 1992. Paloenvironmental, paleontologic and stratigraphic significance of vertebrate remains in Pleistocene limnic and alluvial deposits from South-eastern Sicily. *Palaeogeogr Palaeocl. Palaeoecol.*, 14: 195-208.

Bonfiglio, L., Insacco, G., Marra, A.C. & Masini, F. 1997. Large and small mammals, amphibians and reptiles from a new late Pleistocene fissure filling deposits of the Hyblean Plateau (South Eastern Sicily). *Boll.Soc.Paleont.It.*, 36 (1-2): 97-122.

Burgio, E. 1997. Le attuali conoscenze sui mammiferi terrestri quaternari della Sicilia. In AA.VV., *Prima Sicilia alle origini della società siciliana*: 55-71.

Burgio, E. & Cani, M. 1988. Sul ritrovamento di Elefanti fossili ad Alcamo (Trapani, Sicilia). *Naturalista Siciliano*, 12: 87-97.

Busk, G. 1867. Description of the remains of three extinct species of elephant, collected by Capt. Spratt, C.B.R.N., in the ossiferous cavern of Zebug, in the island of Malta. *Trans. Zool. Soc. London*, 6: 227-306.

Capasso Barbato, L., Minieri, M.R. & Petronio, C. 1989. Resti di mammiferi endemici nelle grotte del Faraglione di Favignana (Egadi, Trapani). *Il Naturalista Siciliano*, 4 (12-1988) (3-4): 99-105.

Chilardi, S. 2001. Large-sized and middle-sized elephants from Pleistocene of Sicily: the case of Contrada Fusco (Siracusa, Southeastern Sicily). *This volume*

Davies, P. & Lister, A.M. 2001. *Palaeodoxodon cypriotes*, the dwarf elephnat of Cyprus: size and scaling comparison with *P. falconeri* (Sicily - Malta) and mainland *P. antiquus. This volume.*

Imbesi, M. 1956. Sugli elefanti nani della grotta di Luparello (Palermo). *Atti Congr. INQUA Rome,-Pise 1953*: 443-447.

Kuss, S.E. 1965. Eine pleistozäne Säugetierfauna der Insel Kreta. *Berc. Naturf. Gesell. Fr. im Brisgau*, 55: 271-348.

Melis, R., Palombo, M.R., Mussi, M. 2001. *Mammuthus lamarmorae* (Major, 1883) from Pre-Tyrrhenian deposits of San Giovanni in Sinis (Western Sardinia, Italy). *This volume.*

Palombo, M.R. 1986. I grandi mammiferi pleistocenici delle isole del Mediterraneo: tempi e vie di migrazione. *Boll. Soc. Paleont. Ital.*, 24 (1985) (2-3): 201-224.

Simonelli, V. 1908. Mammiferi quaternari dell'isola di Candia. II. *Mem. Acc. Sc. Ist. Bologna*, 6: 397-405.

Symeonidis, N.K, Theodorou, G.E. & Giannopoulos, V.I. 2001. New data on

Elephas chaniensis (Vamos cave, Chania, Crete). *This volume*.

Theodorou, G. 1983. *The dwarf elephants of the Charkadio cave on the island of Tilos (Dodekanese, Greece).* PhD Thesis Athens University: 231 pp.

Theodorou, G.E. 1988. Environmental factors affecting the evolution of island endemics: The Tilos exemple for Grece. *Modern Geology*, 13: 183-188.

Vaufrey, R. 1929. Les Eléphants nains des îles meditérranéennes et la question des isthmes pléistocène. *Archiv. Inst. Paléont. Hum.*, 6: 1-220.

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Paedomorphic features and allometric growth in the skull of *Elephas falconeri* from Spinagallo (Middle Pleistocene, Sicily)

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SUMMARY: In *Elephas falconeri* Busk, 1867, the peculiar features of the skull derive from the extensive development of the brain case. This is necessary to maintain a minimal functional volume of the brain when the size of the skull is very reduced. Therefore, the respiratory axis acquires a forward and downward inclination. This feature determines the low position of the external choanae and all the morphology of the braincase, especially the extension of the forehead. On the other hand, the negative allometric growth of the anterior part of the maxillary and premaxillary bones, determines a proportional reduction of the facial region. Juvenile elephant specimens, especially those of *Elephas* and *Loxodonta,* exhibit a skull morphology very similar to that of adult skulls of *E. falconeri*.

1. INTRODUCTION

The richest sample (skulls, mandibles and long bones of several individuals) of the smallest elephant of Sicily *Elephas falconeri* comes from the Middle Pleistocene deposits of Spinagallo cave (Iblean Plateau) (Ambrosetti 1968) where, during the period between 1958 and 1960 (Accordi 1962), a low-diversity, unbalanced and strongly endemic mammal fauna was recovered. The Spinagallo vertebrate fauna has been described in several papers and includes amphibians (*Discoglossus* cf. D. *pictus* Otth, 1837, *Bufo* cf. *B. viridis* Laurenti, 1768, *Hyla* sp.), reptiles (*Testudo hermanni* Gmelin, 1789, *Lacerta viridis* (Laurenti 1768), *Lacerta* sp., probably endemic (cf. *Lacerta siculomelitensis* Boehme & Zammit-Maempel 1982), *Coluber* cf. *C. viridiflavus* Lacépède, 1789, *Natrix* sp.), several species of birds (including giant endemic stringiformes), bats, micromammals (the endemic dormice, *Leithia melitensis* (Adams 1874) and *Leithia cartei* (Adams 1874), and the soricid *Crocidura esuae* Kotsakis 1984), *?Vulpes* sp. and *E. falconeri*, the only large mammal.

The smallest endemic elephants of Malta and Sicily have been considered for decades as the last step of a progressive size reduction trend, started by the mainland species *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley, 1847. Nevertheless, stratigraphic and geochemical data have demonstrated that *Elephas falconeri* is the earliest known endemic elephant in Sicily. Consequently its phylogenetic relationships have been reconsidered. Despite the peculiar morphology of the skull, *E. falconeri* seems to be more closely related to *E. antiquus* than to *Mammuthus* (Palombo, in press).

2. DESCRIPTION AND DISCUSSION

One of the most evident features of the Spinagallo skull is the peculiar proportions between the cranial and facial region of the skull. The proportional increase in size of the cerebral mass observed in the elephants of Spinagallo (Accordi & Palombo 1971), as well as the reduced pneumatization, allow the adult to maintain a rather globose cranium. On the other hand, a functional reduction of the pneumatic bone tissue seems to be a characteristic of dwarfed Proboscidea, especially the smallest ones. For example, in *"Elephas" celebensis* (Hooijer 1949), *Mammuthus exilis* (Stock & Furlong 1928) and *Elephas (Palaeloxodon)* sp from Tilos (Theodorou 1983), this reduction can be detected by the absence of parietal swelling (Roth 1992, 1993; van der Berg *et al.* 1996).

The skull of an adult Spinagallo elephant (Fig. 1c) is characterised by a relatively globose shape with a rather flattened apex; the forehead is wide, almost plane both in sagittal and in transverse profile; the frontal-parietal region is long and very slightly concave. External nasal choanae are in a low position both in juvenile and in adult individuals, being proportionally very large and in a very anterior position with respect to the anterior border of the molar alveolus; orbital cavities take up a very anterior position and are very large, especially in young specimens. The orbital plane is turned towards the outside and it forms a noticeable angle with the sagittal plane; the occipital surface is convex and tilted forward, forming an obtuse angle with the frontal surface. The vertical axis, drawn from the skull vertex, falls in the middle of the molar alveolus in adult specimens, whereas in the juvenile specimens it falls between the posterior border of the molar alveolus and the external

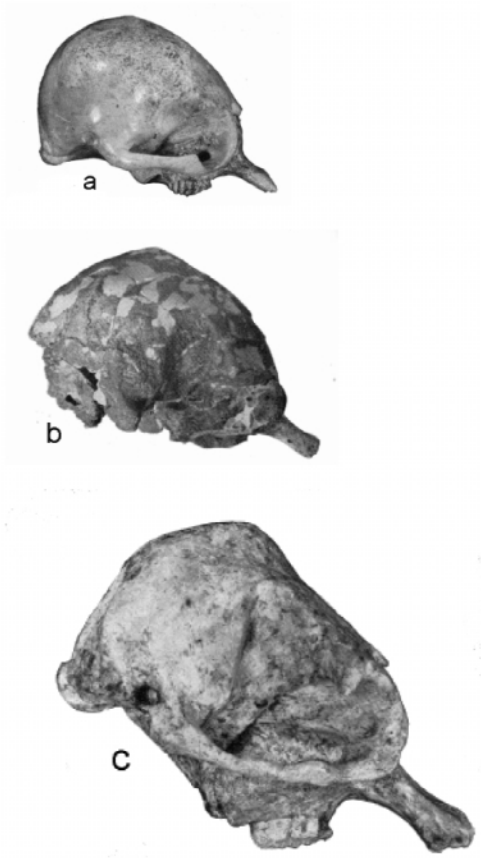

Fig.1 - *Elephas falconeri* Busk, 1867, Spinagallo cave. *E. falconeri* faunal complex, early Middle Pleistocene: skull in lateral view of: (a) very young specimen (n°1) with dp^3 tooth in function; (b) young specimen (n°9) with dp^4 in function (c) adult female (n° 4) with M^2 and M^3 in function. About 0.2x of natural size.

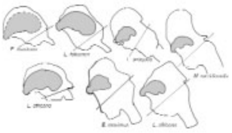

Fig.2 - Cerebral cavity and respiratory axis in: a-b =*Elephas falconeri* Busk, 1867 from Spinagallo cave, a = juvenile (n°2), b = adult female (n°4); c = *Elephas antiquus* Falconer & Cautley, 1847; d = *Mammuthus meridionalis* (Nesti, 1825); e-f *Loxodonta africana* (Blumenbach, 1797), e = foetal individual, f = adult; g = *Elephas maximus* Linnaeus, 1758. Not to scale.

auditory meatus.

A characteristic feature of the Spinagallo skulls is the position of the plane of the tusk alveoli under the forehead plane, slightly turned upward and forward. The tusk alveoli of the Spinagallo specimens are characterised by minimal proximal-distal elongation in comparison with the size of the skull; intermaxillary bones are moderately enlarged with a convex distal edge in the male, reduced with shallow median fossa in the female. The alveolar plane is below the fronto-parietal plane; and the premaxillary bones, in the regionwhich delimits the external choanae, form a noticeable angle with the proximal part of the tusk alveoli.

To explain the peculiar characters of the Spinagallo skulls, the most important and determining element is the allometric growth of the cranial and facial regions of the skull, which differs from that of continental elephant species.

At Spinagallo, during ontogenetic development (Fig. 1), the morphological and biometric variation of the maxillary region and, as a whole, of the skull base, are similar to those displayed by continental elephants, being characterised by a positive allometric development. In very young and young specimens, the palate is wide and transversely flattened, the molar alveoli are slightly protruding, and their lingual sides are almost parallel. During growth, the space between the molars becomes more and more deep and narrow, the alveoli converge forwards, and the height of the posterior maxillary bones notably increases. Consequently, a strong heightening of the occipital condyles can be detected, whereas the inclination of the zygomatic arches increases. This modification results from the need to make room for increasingly tall and wide teeth. The ontogenetic modification of the fan-shaped tusk sockets and triangular, flattened area between them is similar to that of the continental ancestor, but a strong negative allometry and a retardation of somatic development reduce its proportions. Short tusk alveoli are typical of juvenile skulls of elephantine species, in fact this character is related to the small tusk size. Nevertheless, in the male skulls of Spinagallo, the fan, even if rather short, is larger and broader: the distal lateral edge extends almost as far as the lateral extremity of maxillary bones.

In the continental taxa, during ontogenetic growth, the cranial region of the skull displays the greatest positive allometric change (cf. Maccagno 1962). The frontal and parietal bones greatly increase in thickness; the forehead changes its curvature; the brain case volume notably decreases in proportion to the skull size, allowing the rotation of the respiratory axis upward and backward; and the condyles and auditory meatus move into a higher position because of the increased posterior growth of the maxillary bones. Moreover, in adult skulls the external choanae move to a more backward position, the post-orbital region of the forehead becomes less wide, the maxillary region extends, and the angle between forehead and molar alveolar plane changes to a greater or lesser degree. In contrast, the Spinagallo adult skull maintains a relatively very large cerebral mass, whereas its decrease is strongly marked in other elephants. The relative larger size of the brain of the Spinagallo specimens, with respect to the ancestor, is primarily due to the impossibility of proper brain function below a critical volume, as well as to the strong reduction in pneumatisation of the parietal and frontal bones. Consequently, the whole architecture of the adult skull is modified and exhibits some paedomorphic features, such as an overall globose shape, similar to young animals. According to Gould (1977) a large brain, "*by its own mechanical pressure, causes correlated features*" such as a short face, a vaulted cranium and a low foramen magnum. The absence of the latter character in the Spinagallo skull is consistent with the persistence of a positive allometric heightening of the posterior maxillary region.

Notwithstanding some different features, the skull of Spinagallo is, at least apparently, more similar to juvenile specimens of *Elephas*, *Loxodonta* and, in less degree, of *Mammuthus*, than to adult ones, even if some affinities with *Elephas antiquus* can de detected (Palombo, in press).

3. Conclusion

In *Elephas falconeri*, the peculiar features of the skull derive from the extensive development of the brain case, connected to the need for maintaining a minimal functional volume of the brain even when the overall dimensions of the skull are very reduced. The allometric positive size increase of the skull affects the posterior region of the maxillary bones (which increase in height to the edge of the molar alveoli) more than the cranial and facial region of the skull. Consequently in the skull of *E. falconeri*, the inclination of the respiratory axis does not change much: the angle formed with the molar plane increases during growth from 23° in very young specimens, to 40° in the adult male. The forward extension of the brain case prevents the rotation of the respiratory axis upward and backward. Accordingly, the external nasal choanae, as well as the orbits, keep a very low position, while the forehead is very broad and longitudinally extended. Furthermore, the anterior position of the braincase prevents the temporal fossa from deepening and the forehead from narrowing transversely. Conversely, juvenile elephant specimens, especially those of *Elephas* and *Loxodonta*, exhibit a skull morphology very similar to that of adult *E. falconeri.*

4. References

Accordi, B. 1962. La grotta ad elefanti nani di Spinagallo (Siracusa). *Atti Acc. Sc.Ferrara,* 37: 9-15.

Accordi, F.S. & Palombo, M.R. 1971. Morfologia endocranica degli elefanti nani pleistocenici di Spinagallo (Siracusa) e comparazione con l'endocranio di *Elephas antiquus*. *Rend. Accad. Naz. Lincei* s. 8, 51: 111-124.

Ambrosetti, P. 1968. The Pleistocene dwarf elephants of Spinagallo (Siracusa, Sicily). *Geol. Romana* 7: 277-398.

Berg van der , G.D., Sondaar, P.Y., de Vos, J. & Aziz, F. 1996. The proboscideans of the South-East Asian islands. In Shoshani, J. & Tassy, P. (eds.), *The Proboscidea.* cap.22: 240-248. Oxford: Oxford University Press.

Gould, S.J. 1977. *Ontogeny and Phylogeny*: 499 pp. Harward: Belknap Press.

Maccagno, A.M. 1962. Gli elefanti fossili di Riano (Roma). *Geol. Romana,* 1: 33-131.

Palombo. M.R. in press. *Elephas, Mammuthus, Loxodonta, who is the true ancestor of the* *dwarf elephant of Sicily?* Deansea.

Roth, V.L. 1992. Inferences from allometry and fossil dwarfing of elephants of islands. *Surveys in Evolutionary Biology* 8: 259-288. Oxford.

Roth, V.L. 1993. Dwarfism and variability in the Santa Rosa Island mammoth: an interspecific comparison of limb bone sizes and shapes in elephants. In Hochberg, F.G. (ed.), *Third Califonrnia Islands symposium: recent advances in research on the California Islands*: 433-442. Santa Barbara: Santa Barbara Museum of Natural History.

Theodorou, G. 1983. *The dwarf elephants of the Charkadio cave on the island of Tilos (Dodekanese, Greece). PhD Thesis Athens*

The Middle Pleistocene fossil avifauna from the "*Elephas mnaidriensis* Faunal Complex" of Sicily (Italy): preliminary results

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SUMMARY: Preliminary results of the analysis of fossil bird remains from the late Middle Pleistocene-early Late Pleistocene localities of Sicily referred to the "*Elephas mnaidriensis* Faunal Complex" are presented. Several Sicilian sites have yielded fossil vertebrates attributed to this Faunal Complex, but the bird remains analysed in this paper came from only three localities: K-22 (S. Vito lo Capo, north-western Sicily), Acquedolci (northern Sicily) and Contrada Fusco (Siracusa, south-eastern Sicily). Preliminary results show the presence of fifty taxa, three of them extinct: *Gyps melitensis, Cygnus falconeri* and *Grus* cf. *G. melitensis*, the latter two endemic to Sicily and Malta. The fossil bird associations allow us to confirm the insular characteristics of the "*Elephas mnaidriensis* Faunal Complex", already suspected from the analysis of other fossil vertebrates.

1. INTRODUCTION

During the last two centuries, many Sicilian localities with fossil vertebrate assemblages have been found and excavated (Bonfiglio & Burgio 1992). Based on palaeontological analysis, the Pleistocene vertebrates have been arranged into five faunal complexes: the "Monte Pellegrino Faunal Complex" of the Early Pleistocene, the "*Elephas falconeri* F. C." of the early Middle Pleistocene, the "*Elephas mnaidriensis* F.C." of the late Middle Pleistocene-early Late Pleistocene, and the "Pianetti-S. Teodoro F.C." and "Castello F. C." of the Late Pleistocene (Bonfiglio *et al.* 2001). Four of these include mainly endemic fossil mammals, like the pigmy *Elephas falconeri* and the giant glirid *Leithia melitensis* of the "*Elephas falconeri* F. C."; and the dwarf, if less reduced in size *Elephas mnaidriensis* and the pygmy *Hippopotamus pentlandi* of the "*Elephas mnaidriensis* F. C."; plus reptiles and amphibians. The fifth, dating from the latest Pleistocene, contains extant continental species accompanied by Palaeolithic artefacts (Bonfiglio *et al.* 1997, Di Maggio *et al.* 1999). Fossil bird remains were found in each faunal complex (Bonfiglio & Insacco 1992, Bonfiglio *et al.* 1997), except in the oldest one, the "Monte Pellegrino Faunal Complex" which contains only small mammals and reptiles (Burgio & Fiore 1997).

Vertebrate remains of the "*Elephas mnaidriensis* Faunal Complex" have been found in several Sicilian localities (Bonfiglio & Burgio 1992, Mangano & Bonfiglio 1998), which contain essentially macromammals. At the present time the "*Elephas mnaidriensis* F. C." is characterised by the following taxa: *Discoglossus* cf. *D. pictus, Testudo hermanni, Emys orbicularis, Lacerta siculimelitensis, Natrix* sp., Aves, *Leithia* ex gr. *melitensis-cartei, Maltamys wiedincitensis, Crocidura esuae, Crocuta crocuta spelaea, Panthera leo spelaea, Canis lupus, Lutra trinacriae, Ursus arctos, Elephas antiquus leonardii, Elephas mnaidriensis, Sus scrofa, Hippopotamus pentlandi, Cervus elaphus siciliae, Dama carburangelensis, Bos primigenius siciliae* and *Bison priscus siciliae* (Abbazzi *et al.* 2001, Bonfiglio *et al.* 1997, Di Maggio *et al.* 1999). The bird remains are still undescribed, apart for a preliminary analysis of few remains from the "*Elephas mnaidriensis* F.C." locality of Contrada Fusco (Basile & Chilardi 1996) made by Cassoli & Tagliacozzo (1996).

In this paper the preliminary results of a recent analysis on the fossil birds of Sicily are presented, in particular those of the "*Elephas mnaidriensis* F.C." (Pavia 2000).

2. RESULTS

The fossil remains analysed here come from three Sicilian localities (Fig. 1): K22, a fissure filling exposed in an abandoned quarry in the S. Vito Lo Capo peninsula, North-western Sicily (Di Maggio *et al.* 1999), which yielded some bird remains from the levels attributed to the "*Elephas mnaidriensis* F. C."; Acquedolci, a lacustrine deposit located in Northern Sicily with very rich vertebrate remains dominated by *Hippopotamus pentlandi* (Bonfiglio 1995), from which only a proximal ulna of *Gyps melitensis* has been found; and Contrada Fusco, a lacustrine deposit outcropping in the suburbs of Siracusa (Basile & Chilardi 1996), in which hundreds of bird remains have been collected, the study of which is still in progress (Pavia & Chilardi, in prep.).

Preliminary palaeontological analysis of the fossil bird remains of these localities allows me to indicate the bird taxa of the "*Elephas mnaidriensis* Faunal Complex" as follows (the † indicates the extinct taxa):

Tachybaptus ruficollis
Podiceps cristatus
Podiceps auritus
Phalacrocorax carbo
Pelecanus crispus
Ixobrychus minutus
Botaurus stellaris
Egretta garzetta
Ardea cinerea
Plegadis falcinellus
Cygnus falconeri (†)
Anser sp.
Branta sp.
Tadorna tadorna
Anas crecca/querquedula
Anas platyrhynchos
Anas clypeata
Anas sp.
Aythya sp.
Mergus merganser
Oxyura leucocephala
Buteo buteo
Gyps melitensis (†)
Accipiter gentilis
Accipiter nisus
Aquila sp.
Pandion haliaetus
Falco columbarius
Coturnix coturnix
Fulica atra
Grus grus
Grus cf. *G. melitensis* (†)
Tetrax tetrax
Otis tarda
Limosa limosa/lapponica
Numenius cf. *N. phaeopus*
Scolopax rusticola
Tringa sp.
Pterocles orientalis
Columba livia/oenas
Bubo bubo
Strix aluco
Athene noctua
Tachymarptis melba
Coracias garrulus
Anthus sp.
Erithacus rubecula
Turdus sp.
Sylvia sp.
Sturnus unicolor/vulgaris
Corvus corone

3. CONCLUSIONS

Palaeontological analysis of the fossil bird remains of the "*Elephas mnaidriensis* Faunal Complex" reveals the presence of at least fifty taxa, three of them extinct: *Gyps melitensis*, *Cygnus falconeri* and *Grus* cf. *G. melitensis*, the latter two endemic of Sicily and Malta.

The findings of *Cygnus falconeri* at Contrada Fusco represent the first report of this taxon outside the Maltese Archipelago. This species was described by Parker (1865, 1869) from cave deposits in Malta in which dwarf elephants and endemic Gliridae of the genera Leithia and Maltamys were also found (Northcote 1982). The Sicilian remains of *Cygnus falconeri*, together with the remains of *Cygnus equitum* and *Grus melitensis* from other Sicilian localities (Pavia 2000), confirm the affinities between the Maltese vertebrate faunas and the Sicilian ones, as indicated by Kotsakis (1986) based on the analysis of other vertebrate remains. In fact some endemic vertebrates have been reported from both Sicily and Malta, such as *Elephas falconeri*, *E. mnaidriensis*, *Leithia melitensis*, *Maltamys wiedincitensis* and *Lacerta siculimelitensis* (Caloi *et al.* 1988).

The fossil avifauna of the “*Elephas mnaidriensis* Faunal Complex” shows the typical features of insular avifaunas, as described by Alcover *et al.* (1992): (a) the presence of endemic forms, *Cygnus falconeri* and *Grus* cf. G. *melitensis*, (b) the absence of Galliforms, with the exception of the migrating *Coturnix coturnix*, and (c) the absence of species of the genus *Passer*. In the “*Elephas mnaidriensis* F. C.” three species of Strigiforms are reported: *Strix aluco*, *Bubo bubo* and *Athene noctua*; all are continental species and the latter two partially substitute two endemic Strigiforms that inhabited Sicily during the Middle Pleistocene and are found in the localities of the “*Elephas falconeri* Faunal Complex” (Pavia 1999, 2000; Pavia & Mourer-Chauviré 2000). The avifauna of the Middle Pleistocene-Late Pleistocene “*Elephas mnaidriensis* Faunal Complex” of Sicily, even if it maintains the insular characteristics, shows a reduction of the degree of isolation, testified by the decrease in endemic forms and the arrival of new continental forms, like the Strigiforms and the big scavenger *Gyps melitensis*, that probably followed the colonisation of Sicily by the large mammals typical of the “*Elephas mnaidriensis* Faunal Complex”. The reduction of the degree of isolation is also evident in the mammal fauna, testified among others by the extinction of the dwarf *Elephas falconeri* and its replacement by the less size-reduced *E. mnaidriensis*, and the occurrence of some large mammal taxa, slightly modified compared to their continental ancestor, such as *Bos primgenius siciliae* an *Cervus elaphus siciliae*. The completion of the analysis of the bird remains will allow us to appraise the structure of the association and its relationship to the other Sicilian FC and to the mainland avifaunas. Finally, a comparative analysis of the Sicilian fossil bird associations and the Maltese ones will allow us to clarify the similarities between the two islands and their vertebrate faunas.

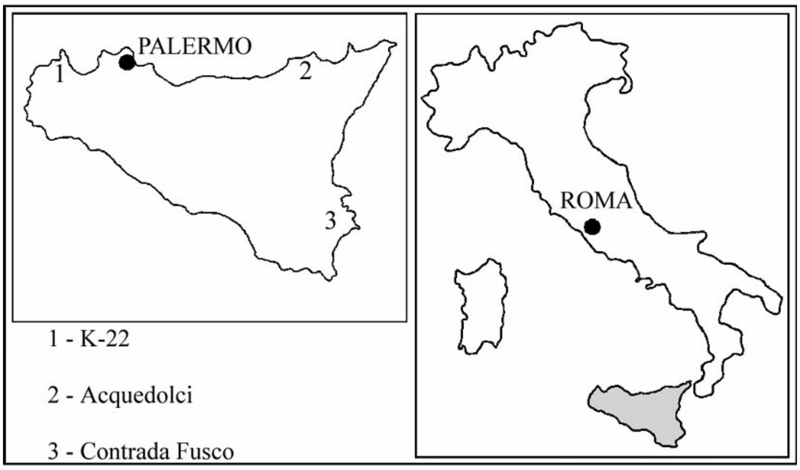

Fig.1 - Map of Sicily with the localities cited in the text.

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5. REFERENCES

Abbazzi, L., Bonfiglio, L., Marra, A.C. & Masini, F. 2001. A revision of medium and small sized deer from the Middle and Late Pleistocene of Calabria and Sicily. In Rook L. & Torre D. (eds.), Neogene and Quaternary continental stratigraphy and mammal evolution. Papers in honour of Prof. Augusto Azzaroli's outstanding contribution in Geology and Palaeontology. *Bollettino Società Paleontologica Italiana* 40 (2): 115-126.

Alcover, J.A., Florit, F., Mourer-Chauviré, C. & Weesie, P.D.M. 1992. The avifaunas of the isolated Mediterranean islands during the Middle and Late Pleistocene. *Science Series Natural History Museum Los Angeles County* 36: 273-283.

Basile, B. & Chilardi, S. (eds.) 1996. *Siracusa, le ossa dei giganti, lo scavo paleontologico di Contrada Fusco.* Siracusa: Arnaldo Lombardi.

Bonfiglio, L. 1995. Taphonomy and depositional setting of Pleistocene mammal-bearing deposits from Acquedolci (North-Eastern Sicily). *Geobios M.S.* 18: 57-68.

Bonfiglio, L. & Burgio, E. 1992. Significato paleoambientale e cronologico delle mammalofaune pleistoceniche della Sicilia in relazione all'evoluzione paleogeografica. *Il Quaternario* 5 (2): 223-234.

Bonfiglio, L. & Insacco, G. 1992. Palaeoenvironmental, palaeontologic and stratigraphic significance of vertebrate remains in Pleistocene limnic and alluvial deposits from southeastern Sicily. *Palaeogeogreography, Palaeoclimatology, Palaeoecology* 95: 195-208.

Bonfiglio, L., Insacco, G., Marra, A.C. & Masini, F. 1997. Large and small mammals, amphibians and reptiles from a new late Pleistocene fissure filling deposit of the Hyblean Plateau (South Eastern Sicily). *Bollettino Società Paleontologica Italiana* 36 (1-2): 97-122.

Bonfiglio, L., Mangano, G., Marra, A.C. & Masini, F. 2001. A new Late Pleistocene vertebrate faunal complex from Sicily (S. Teodoro Cave, North-Eastern Sicily, Italy). In Rook L. & Torre D. (eds.), Neogene and Quaternary continental stratigraphy and mammal evolution. Papers in honour of Prof. Augusto Azzaroli's outstanding contribution in Geology and Palaeontology. *Bollettino Società Paleontologica Italiana* 40 (2): 149-158.

Burgio, E. & Fiore, M. 1997. Mustelercta arzilla (De Gregorio, 1886) elemento villafranchiano nella fauna di Monte Pellegrino (Palermo, Sicilia). *Il Quaternario* 10 (1): 65-74.

Caloi, L., Kotsakis, T. & Palombo, M.R. 1988. La fauna a vertebrati terrestri del Pleistocene delle isole del Mediterraneo. *Geologica Romana* 25 (1986): 235-256.

Cassoli, P.F. & Tagliacozzo, A. 1996. L'Avifauna. In B. Basile & S. Chilardi (eds.), *Siracusa, le ossa dei giganti, lo scavo paleontologico di Contrada Fusco*: 61-67. Siracusa: Arnaldo Lombardi.

Di Maggio, C., Incandela, A., Masini, F., Petruso, D., Renda, P., Simonelli, C. & Boschian, G. 1999. Oscillazioni eustatiche, biocronologia dei depositi continentali quaternari e neotettonica nella Sicilia Nord-occidentale (Penisola di S. Vito Lo Capo – Trapani). *Il Quaternario* 12 (1): 25-49.

Kotsakis, T. 1986. Vertebrati insulari e paleogeografia: alcuni esempi. *Bolletino Società Paleontologica Italiana* 24 (2-3): 225-244.

Mangano, G. & Bonfiglio, L. 1998. I depositi a vertebrati continentali del Pleistocene della Sicilia orientale. *Naturalista siciliano*, S.

IV, 22 (3-4): 405-432.

Northcote, E.M. 1982. Size, form and habit of the extinct Maltese Swan *Cygnus falconeri*. *Ibis* 124: 148-159.

Parker, W.K. 1865. Preliminary note on some fossil birds from the Zebbug Cave, Malta. *Zoological Society of London Proceedings* 1865: 752-753.

Parker, W.K. 1869. On some fossil birds from the Zebbug Cave, Malta. *Transactions Zoological Society of London* 6: 119-124.

Pavia, M. 1999. The Middle Pleistocene Avifauna of Spinagallo Cave (Sicily, Italy): Preliminary report. In S.L. Olson (ed.), Avian Paleontology at the Close of the 20th Century: Proceedings of the 4th International Meeting of the Society of Avian Palaeontology and Evolution, Washington, D.C., 4-7 June 1996. *Smithsonian Contribution to Paleobiology* 89: 125-127.

Pavia, M. 2000. *Le avifaune pleistoceniche dell’Italia meridionale*. Unpublished PhD Thesis, University of Torino: 147 pp.

Pavia, M. & Mourer-Chauviré, C. 2000. An overwiev on the genus Athene in the Pleistocene Mediterranean Islands with the description of a new species (Aves, Strigiformes). *Vertebrata Palasiatica* 38 (Supplement): 24-25.

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Scaling of proximal limb bones between *Elephas antiquus* and its insular descendant *Elephas falconeri*

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SUMMARY: In this study we have calculated allometric equations for the scaling of linear dimensions (length and diameter) of the proximal elements of limbs in *Elephas antiquus* and of its insular descendant *Elephas falconeri.* We have found that the legs of these closely-related elephants species of the Middle and the Late Pleistocene scale according to the geometric similarity model. According to this model, all linear dimensions scale proportionally to the mass raised to the 1/3 power, so the relationship between them is independent of mass. By the same token, our results contradict other theoretical models such as elastic similarity. Some mechanical consequences of geometric similarity are discussed.

1. INTRODUCTION

Due to the scaling of physical, ecological and metabolic factors, large mammals are rather different from those of small size. Since Kleiber (1932) showed that the metabolic demands of mammals scale according to $M^{3/4}$, where M is the body mass, a number of studies have been devoted to the effects of scaling or allometry. The surface area of the body, and the cross-sectional area of bones, muscles and tendons, all scale with the square of linear dimensions, while the mass scales with the cube. Because of this simple relationship, large mammals have, in addition, a smaller mass-specific resting metabolism, while life span or age of first reproduction, are increased (Alexander 1992; Biewener 1989, 1990; Calder 1996; Damuth 2001; Gould 1975; Hildebrand 1995; Norris 1998; Pollock *et al.* 1994; Promislow & Harvey 1990; Sinervo *et al.* 2000; Stearns 1983, West *et al.* 1997). The purpose of this study is to examine scaling in linear dimensions (length and diameter) in the proximal limb bones of the extinct European elephant *Elephas antiquus*, Middle to Late Pleistocene in age. We concentrate on the notable size reduction that has occurred in the evolution of *E. antiquus* in Sicily, where it is recognised to have given rise to a separate species, the dwarf elephant, *Elephas falconeri.*

2. MATERIALS AND METHODS

We have collected, in part from the literature (Maccagno 1962, and references therein; Ambrosetti 1968), up to 51 measurements of the length and the cross-sectional diameter at the midshaft of humeri and femurs of *E. antiquus* and its insular descendant *E. falconeri*. Measurements of the latter are on specimens from the Spinagallo caves (Sicily, Italy) previously described by Ambrosetti (1968). We have re-measured bones of *E. falconeri*, now held at the University of Catania (Sicily). One of us (M.C.) has taken further measurements from limb bones of *Elephas antiquus* recovered from the lacustrine basin of Mercure (Lucania, Italy). Professor Paul Mazza, University of Florence, kindly gave us further measurements. We have reported exclusively data regarding adult individuals, i.e. we restricted our sample to long bones with fused epiphyses. This avoids the confounding effect of differential growth during ontogeny.

We transformed our data to logarithms and performed least squares regressions, plotting bone midshaft diameter versus total length. The exponents of the allometric equations have been appraised in comparison with the expectations of common scaling models (Alexander *et al*. 1979; MacMahon 1973, 1975). Because the data of Alexander *et al.* (1979) were obtained with mass as the dependent variable, we devised a simple arithmetic transformation, by dividing Alexander *et al.*'s general equations by each other. This allows direct comparison to our equations, which were obtained using two linear dimensions.

3. Sources of Error

Fossil bones are not fresh bones. Since we rely upon linear measures, we need to consider whether taphonomic processes could have altered bone proportions. We have not found any mention in the literature that the diameters of bones are somehow more or less easily weathered than their lengths. Indeed, diaphyses are formed from lamellar bone, whereas epiphyses are formed from trabecular bone. To avoid the possibility that the different responses of those tissues to diagenetic stresses may have influenced our equations, we have chosen to limit ourselves to data from well-preserved bones. Unfortunately, this slightly limits our sample, especially concerning *E. antiquus* specimens. Many studies suggest allometric equations are valid even within a single genus (e.g. Woodhead & Reiss 1991). Moreover, since the data cover a large size span (*E. falconeri* was close to 10^{-2} times the mass of *E. antiquus* according to the estimates made by Roth 1990), we consider our equations to be reliable (Calde 1996). Nonetheless, the biological interpretation of allometric relationships is still the subject of debate (Kozlowsky & Weiner 1997; West *et al.* 1997). And since we have taken some data from the literature, we have repeated possible authors' errors in measuring and/or reporting bone dimensions.

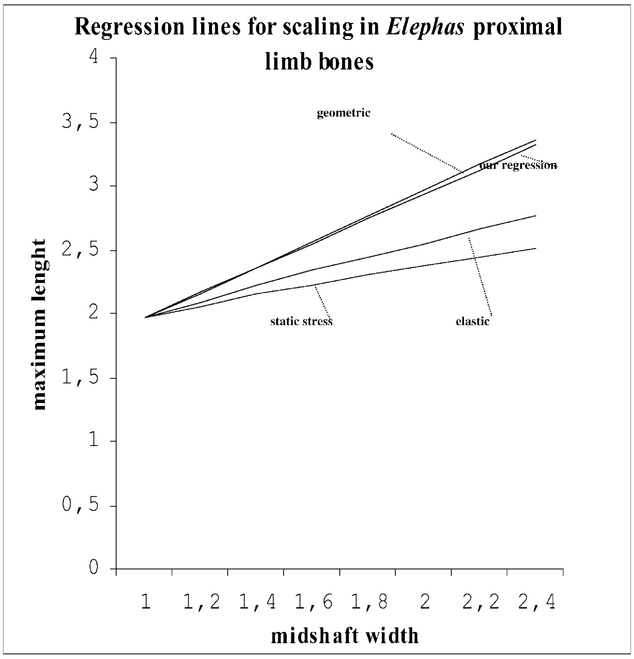

Fig.1 - Logarithmic plot of our general equation (see text for explanations) for proximal limb bone width at midshaft versus bone total length for the species *Elephas falconeri* and *Elephas antiquus*. Regression lines predicted by common scaling models are also plotted for comparison.

4. RESULTS

For the humerus, we have found $l = 5.11\ d^{1.115}$, $r = 0.981$, $n=24$; for the femur; $l = 13.97\ d^{0.889}$, $r = 0.972$, $n = 27$; and overall (adding humerus to femur data) $l = 9.183\ d^{0.979}$, $r = 0.958$, $n = 51$. In these equations, l is the length of the bone and d the diameter, in millimeters. The exponents are all very close to 1, that is, length and diameter scale isometrically.

The slight differences between the humerus and femur exponents are hardly significant, and may be due only to sample bias. Most significantly, they differ markedly from exponents predicted by models other than geometric similarity (see below). At first glance, this result is amazing. If the model of geometric similarity is valid, the linear dimensions both scale to the 1/3 power of the mass. Thus, dividing between them, we get: $l/d\ \alpha\ M^0$, that is, the ratio of length to diameter scales independently of mass. Alexander *et al.* (1979) obtained a very similar result. From their equations, we calculate $l/d\ \alpha\ M^{-0.01}$, for limb bones across all mammals. This corresponds to our $l\ \alpha\ d^{0.979}$. However, as is easily seen, body weight loads limb bone cross-sectional area in direct proportion to mass (i.e. to mass to the power of one), whence cross-sectional area itself scales to the 2/3 power of the mass, and expected stress scales to $M^1/M^{2/3} = M^{1/3}$.

5. DISCUSSION

McMahon (1973, 1975) proposed that, to respond elastically with similar deformations, limb bones (and the whole limb) had to scale according to the relationship $d\ \alpha\ l^{3/2}$, a model named elastic similarity. Since we have calculated around a fourfold difference between lengths and diameters of humeri and femurs of *Elephas antiquus* and *E. falconeri*, the observed midshaft widths of the latter are up to two times greater than expected under the elastic similarity model, (see appendix 1).

As shown by Biewener (1989), large mammals tend to compensate for the increase in relative stress loading their limb bones with postural adaptations. Large mammals have more erect legs, so that the body weight is more vertically loaded upon them. A better moment arm advantage is thereby provided for the leg muscles. This is expected to produce a rather conservative average stress on bones (Biewener 1989, 1990). Lower body weight allows small mammals to adopt a more crouched posture (Alexander 1992). Biewener (1989, 1990) demonstrated that these adaptations are sufficient up to around 300 kg, and that above this limit large animals adapt by sacrificing a large part of their cursorial performance to the needs of support. Moreover, for the heaviest mammals, such as rhinos, Biewener (1990) found limbs to follow an allometric relationship named static stress similarity, in which $l\ \alpha\ d^{1/2}$. Hildebrand (1994) further indicated 900 kg as a critical limit, beyond which limbs become columnar. Examining our data in the light of these models, the width of proximal limb bones of *E. falconeri* appears increased even if compared to the predictions of static stress similarity, which supposedly governs scaling in both extant elephants and *Elephas antiquus*. But *E. falconeri* limbs do not appear stouter than those of extant mammals of comparable size (see, for example, data reported in McMahon 1975 and Scott, 1990). Our results suggest that elastic similarity does not occur in the evolution of limbs from *E. antiquus* to *E. falconeri* during the Middle Pleistocene of Sicily (Fig. 1; Belluomini & Bada 1985). Indeed, elastic similarity seems not to apply if one deals with any mammals other than bovids (Hildebrand 1994). Since only postural changes have occurred in limbs, despite the great size reduction in the evolution of *E. antiquus* to *E. falconeri* (diameter/length ratios remain constant, at least for humerus and femur), we suggest that *E. falconeri* could move in more agile manner (maybe through less constrained articular movements) than *E. antiquus*. It is worth noticing that this suggestion agrees with the findings of Caloi & Palombo (1994) and Palombo (1996) for the elephants of Spinagallo. In keeping with this, Calder (1996, p.166) shows that in mammals, the angle in the sagittal plane covered by the legs during movement, decreases with size.

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7. REFERENCES

Alexander McNeill, R. 1984. Walking and running. *American Scientist* 72: 348-355.

Alexander McNeill, R. 1992, *Exploring biomechanics, Animal in motion*: 250pp. USA: Scientific American Library.

Alexander McNeill, R., Jayes, A.S., Maloiy, G.M.O., Wathuta, E.M. 1979. Allometry of the limb bones of mammals from shrew (*Sorex*) to elephant (*Loxodonta*). *Journal of Zoology* 189: 305-314.

Ambrosetti, P. 1968. The Pleistocene dwarf elephants of Spinagallo (Siracusa, South-Eastern Sicily). *Geologica Romana*, 7: 277-398.

Belluomini, G., Bada, J.L. 1985, Isoleucine epimerization ages of the dwarf elephants of Sicily. *Geology* 13(7): 451-52.

Biewener, A.A. 1989. Scaling body support in mammals: limb posture and muscle mechanics. *Science* 245(4913): 45-8.

Biewener, A.A. 1990. Biomechanics of mammalian terrestrial locomotion. *Science* 250: 1097-1103.

Caloi, L., Palombo, M.R. 1994. Functional aspects and ecological implications in Pleistocene endemic herbivores of mediterranean islands. *Historical Biology* 8: 151-172.

Calder, W. 1996. *Size, Function, and Life History.* New York: Dover edition.

Damuth, J. 2001. Scaling of growth: plants and animals are not so different. *PNAS* 98 (5): 2113-14.

Gould, S.J. 1975. On the scaling of tooth size in mammals. *American Zoologist* 15: 351-62.

Hildebrand, M. 1987. The mechanics of horse legs. *American Scientist* 75: 594-601.

Hildebrand, M. 1995. *Analysis of Vertebrate Structure*. 4th ed. John Wiley & Son.

Maccagno, A.M. 1962, Gli elefanti fossili di Riano (Roma). *Geologica Romana* 1: 33-132.

McMahon, T. 1973. Size and shape in biology. *Science* 179: 1201-04.

McMahon, T. 1975. Allometry and biomechanics: limb bones in adult ungulates. *American Naturalist* 109: 547-63.

McNab, B.K. 1988. Complication inherent in scaling the basal rate of metabolism in mammals. *Quarterly reviews of Biology* 63(1): 25-54.

Myers, M.J., Steudel, K. 1997. Morphological conservation of limb natural pendular period in the domestic dog (*Canis familiaris*): implications for locomotor energetics. *Journal of Morphology* 234(2): 183-96.

Norris, S. 1998. Of mice and mammoths. *Bioscience* 48(11): 887-893.

Palombo, M.R. 1996. Large Pleistocene mammals of the mediterranean islands. *Vie et Milieu* 46: 365-74.

Petersen, J.E., Hastings, A., Morin, P.J. 2001. Dimensional approaches to scaling experimental ecosystems: designing mousetraps to catch elephants. *American Naturalist* 157(3): 324-334.

Pollock, C.M., Shadwick, R.E. 1994. Allometry of muscle, tendon, and elastic energy storage capacity in mammals. *American J. Physiology* 266(3Pt2): R1022-31.

Promislow, D.E.L., Harvey, P.H. 1990. Living fast and dying young: A comparative analysis of life history variation among mammals. *Journal of Zoology* 220: 417-437.

Roth, L. 1990. Island dwarf elephants: a case study in body mass estimation and ecological inference. In Damuth, J. MacFadden B. (eds.), *Body size in Mammalian Paleobiology*: 151-179. Cambridge: Cambridge University Press.

Sinervo, B., Svensson, E., Comendant, T. 2000. Density cycles and an offspring quantity and quality game driven by natural selection. *Nature* 406: 985-88.

Stearns, S.C. 1983. The influence of size anf phylogeny on patterns of covariation among life-history traits in the mammals. *Oikos* 41: 173-187.

West, G.B., Brown, J.H., Enquist, B.J. 1997. A general model for the origin of allometric scaling laws in biology. *Science* 276: 122-126.

Woodhead, V., Reiss, M. 1991. An investigation of the effect of body mass on resting heart rate in dogs. *J. Biological Education* 25(1): 33-37.

APPENDIX 1 – CALCULATED STATISTICS (all measurements are in millimeters).

	Femur (length/diameter)			Humerus (length/diameter)		
	n	mean	coeff. of var	n	mean	coeff. of var.
Elephas antiquus	3	1482/182.7	4.93/3.85	4	1230/138.1	5,86/20.87
Elephas falconeri	2	1345/37.2	12.4/15.3	23	286/38.4	12,8/17.9

Ecology and evolution of dwarfing in insular elephants

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SUMMARY: Elephants approach one extreme in the spectrum of terrestrial mammalian body sizes. In the Pleistocene, on islands, they have also undergone size reduction to an extreme degree. An understanding of the evolutionary origins and ecological roles of dwarfed forms of elephants on Pleistocene islands both benefits from, and may allow us to test, general hypotheses about the relationship between (a) body size and (b) the processes involved in organismal function, ecology, and evolutionary mechanisms.

1. INTRODUCTION

Fossils from insular populations of elephants are the most extreme examples of Foster's Island Rule for mammalian body size (Foster 1964, Van Valen 1973, Lomolino 1985): on islands, mammals larger than a rabbit almost invariably evolve smaller body size (whereas mammals of small body size on islands typically enlarge).

Insular elephants are of particular interest because of the magnitude of their reduction in size. The island forms may be half or even one-quarter the shoulder heights of their mainland ancestors, with body mass reduced to just one or a few percent of the original (Roth 1990). This degree of body size reduction is more extreme than that observed for any other insular dwarfs, even allowing for the fact that very large mammals generally undergo proportionately the greatest reduction on islands.

The terms "dwarf" and "pygmy" have both been used, with nearly equal frequency, to denote forms or species of mammals that are smaller in body size than their close relatives (Nowak 1991). I will use the terms synonymously, without intending them to carry any specific implications about the mode or mechanism of size reduction. Dwarfed forms of elephants have been reported from islands off California, Siberia, eastern Asia, and in the Mediterranean–wherever, in fact, elephants have colonized islands free of large predators (Roth 1992; Vartanyan *et al.* 1993).

2. ELEPHANTS ON ISLANDS AS "NATURAL EXPERIMENTS"

The frequency with which elephants have colonized islands and undergone size reduction provides paleoecologists and evolutionary biologists with multiple instances of a natural experiment.

The experimental conditions offered by island habitats typically differ from corresponding habitats on the mainland in their smaller geographic area, their reduced accessibility to colonizing or migrating terrestrial species, and their more equable climate which is moderated by the surrounding water. Island communities often comprise fewer species, in combinations differing from the mainland. The island populations themselves may undergo divergence from their mainland ancestors, giving rise to forms that are distinctive or even unique.

The existence of dwarfed elephants on Pleistocene islands raises a number of questions, in two interrelated categories: 1. By what mechanism(s) did insular elephants attain their diminutive sizes? and 2. What ecological role did elephants weighing just a few hundred kilograms play in their respective communities? Suitable answers to these questions must be consistent with what is known about the differences between conditions on mainland and island, as well as what can be inferred about characteristics of the animals from their fossils.

3. OPEN QUESTIONS

3.1 Evolutionary mechanisms

Mechanisms of change in body size include phenotypic plasticity (stunting, for example in this instance) and genetic divergence. Genetic change can arise through drift and natural selection.

The size difference between the smallest of insular dwarfs and their mainland ancestors was too great to be achieved by stunting alone. Among lineages, the net change is too consistent in direction–exclusively toward smaller size–to be explained by genetic drift, so we infer that natural selection must have been involved.

Natural selection among individuals is generally considered the most efficient and well documented mechanism of evolution; however, selection can in principle operate at multiple levels (such as the gene, organism, or deme). Islands may not have been able to sustain large populations of large-bodied forms, in which case it is plausible that differential extinction of low-density populations (and conversely, persistence of high-density, dwarfed populations) could have played a role in the evolution of insular elephants (Wassersug *et al.* 1979). Evidence of such differential extinction would include islands with deposits of fossils of large elephants overlain by no evidence that the population had any direct descendants.

More conventional explanations of dwarfing focus on selection acting on traits of individuals. Marked dimorphism in *Elephas falconeri* from Sicily (Ambrosetti 1968) provides evidence of the action of sexual selection, as well as natural selection, on dwarfed elephants.

The processes affecting extinct animals cannot be observed directly, but the morphology of the animals can reveal the type of variation on which natural selection may have acted. Contrary to some suggestions, achondroplasia, a type of dwarfing that can be produced by mutation at a single genetic locus, was evidently not involved (Roth 1993). The high frequency of certain dental anomalies known to be common in modern populations that are food-stressed hints at similar stresses in insular populations (Roth 1989). The substantial amounts of morphological variability found within dwarfed elephant populations suggests that small body size, rather than a particular paedomorphic morphology, was the target of selection (Roth 1984, 1993). As more is inferred about the ecology, environment, and life-history of the animals, more informed inferences can be made about the action of natural selection within these populations.

3.2 Natural history

An animal's body size reveals much about its way of life (Peters 1983). At the same time, techniques for the functional analysis of fossils continue to be developed and enhanced, and these allow predictions based on estimates of body mass to be tested. Analysis of stable isotopes and of dental striations may give clues to diet; bone histology may reveal patterns of growth; dentine layers may provide a tally of years that facilitate inferences of lifespan. Among the questions raised about tiny elephants are:

How did they subsist, persist, grow and reproduce? What did they eat? How did the morphology of their teeth and jaws reflect or constrain their diets? What morphological evidence is there of their locomotor agility or greater maneuverability (e.g. Sondaar 1977)? What modifications do they show in their patterns of growth? How was their demography and population structure affected by body size? Among modern mammals many life-history variables are known scale with body size. Do the size-related trends in natural history observed for bovids and other large herbivores also apply to the Elephantidae (Jarman 1974)? For example, did the smallest elephants require food with more highly concentrated nutrients?

How do the characteristics of insular elephants vary in relation to the characteristics of the islands and their biotas?

3.3 Many islands; much time

Ultimately, an understanding of the natural history and evolution of dwarfed elephants must be understood in the context of their history, and the history of the islands they inhabited. Paleontological subjects offer the study of biology a unique perspective from the vantage of lengthy periods of time. The replicated experiments of elephants evolving on islands allow us to observe both variation and patterns. Patterns and regularities in turn allow us to infer more general evolutionary and ecological principles.

As more information emerges about fossil elephants from islands, we will know with increasing confidence which islands supported such populations and which did not; what the relationship is between an island's area, its distance from the mainland, and the body size of its inhabitants; how these quantities varied in place and changed through time; and over what time course the events occurred. These facts will enhance our understanding of the more fundamental processes that govern the evolution of communities, the divergent process of speciation, and the origin of evolutionary novelty.

4. REFERENCES

Ambrosetti, P. 1968. The Pleistocene dwarf elephants of Spinagallo (Siracusa, south-eastern Sicily). *Geol. Rom.* 7: 277-398.

Foster, J.B. 1964. Evolution of mammals on islands. *Nature* 202: 234-235.

Jarman, P.J. 1974. The social organization of antelope in relation to their ecology. *Behaviour* 48: 215-267.

Lomolino, M.V. 1985. Body size of mammals on islands: The island rule reexamined. *Amer. Nat.* 125: 310-316.

Nowak, R.M. 1991. *Walker's mammals of the world* (Fifth ed.). Baltimore: The Johns Hopkins University.

Peters, R.H. 1983. *The ecological implications of body size*. Cambridge: Cambridge University Press.

Roth, V.L. 1984. How elephants grow: heterochrony and the calibration of developmental stages in some living and fossil species. *J. Vert. Paleo*. 4: 126-145.

Roth, V.L. 1989. Fabricational noise in elephant dentitions. *Paleobiology* 15: 165-179.

Roth, V.L. 1990. Insular dwarf elephants: A case study in body mass estimation and ecological inference. In J. Damuth & B.J. MacFadden (eds.), *Body size in mammalian paleobiology: Estimation and biological implications:* 151-179, Cambridge: Cambridge University.

Roth, V.L. 1992. Inferences from allometry and fossils: dwarfing of elephants on islands. In D. Futuyma & J. Antonovics (eds.), *Oxford surveys in Evolutionary Biology* 8: 259-288.

Roth, V.L. 1993. Dwarfism and variability in the Santa Rosa Island mammoth (*Mammuthus exilis*): An interspecific comparison of limb-bone sizes and shapes in elephants. In F.G. Hochberg (ed.), *Third California Islands Symposium*: 433-442, Santa Barbara: Santa Barbara Museum of Natural History.

Sondaar, P.Y. 1977. Insularity and its effect on mammal evolution. In M.K. Hecht, P.C. Goody & B.M. Hecht (eds.), *Major patterns in vertebrate evolution*: 671-707, New York: Plenum.

Van Valen, L.M. 1973. Pattern and the balance of nature. *Evol. Theory* 1: 31-49.

Vartanyan, S.L., Garutt, V.E. & Sher, A.V. 1993. Holocene dwarf mammoths from Wrangel Island in the Siberian Arctic. *Nature* 362: 337-340.

Wassersug, R.J., Yang, H., Sepkoski, J.J.Jr. & Raup, D.M. 1979. The evolution of body-size on islands: a computer simulation. *Amer. Nat.* 114: 287-295.

The World of Elephants - International Congress, Rome 2001

New data on *Elephas chaniensis* (Vamos cave, Chania, Crete)

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SUMMARY: The description of the new species *Elephas chaniensis* Symeonides, Theodorou and Giannopoulos 2000 was published on 9 December 2000 (Syemonides *et al.*, 2000) for the celebration of the 50th anniversary of the Hellenic Speleological Society. The fossil material was collected in the submerged cave of Vamos near Chania, Crete on the southeast of Drepanon Cape at the east side of the Souda Gulf. In this paper we discuss the material collected since the first publication. All available data from the first and recent collections point to the existence of a large but not continental-sized endemic elephant. The material allows us to understand the size variation of the new species. The finds were collected by divers. The submerged cave was open to the air during the last climatic minimum. Today only the upper part of the main chamber is above sea level. All data point to a Late Pleistocene age. Absolute dates are expected to be available in time for the Congress.

1. INTRODUCTION

The cave was found by E. Eythimaki, during underwater fishing. It was filmed by G. Tzanaki and I. Spanos and was first studied by the geologist V. Giannopoulos from the Ministry of Culture, who also discovered the fossil bones. The collected material was transported to the Geological Department of Athens University and was studied by N. Symeonides, G. Theodorou and V. Giannopoulos. Material is still collected during periods of field work. The bones are found at a depth of 1.5 to 4.5 meters, partly in sandstone and partly covered by calcitic material. The first publication included data on elephant bones, and as well as fossil bones of cervids belonging to *Candiacervus* sp, or to the smaller group of De Vos (1979), or close to the lower limit of his ‘size II’. The elephant material is attributed to the new endemic species *Elephas chaniensis*.

2. THE MATERIAL

The first collection includes more than 40 elephant bones. The first impression was that we were dealing with a large elephant, larger than any known specimen from the Rethymno area. It was crucial to know the size variation of the Vamos population or a least to have a good indication. If some bones could be attributed to a large but not continental-sized elephant then we had an endemic population. If all bones were close to the lower – though unknown - limit of continental Late Pleistocene elephants, then we could not exclude the possibility that the newly discovered material could represent the long undocumented occurrence of *E. antiquus* on Crete. Some pieces of unciform, representing three ontogenetic stages from large to small adult animals, gave the first very good indication of the size variation of the population. The material belonged to a large but clearly not continental-sized elephant.

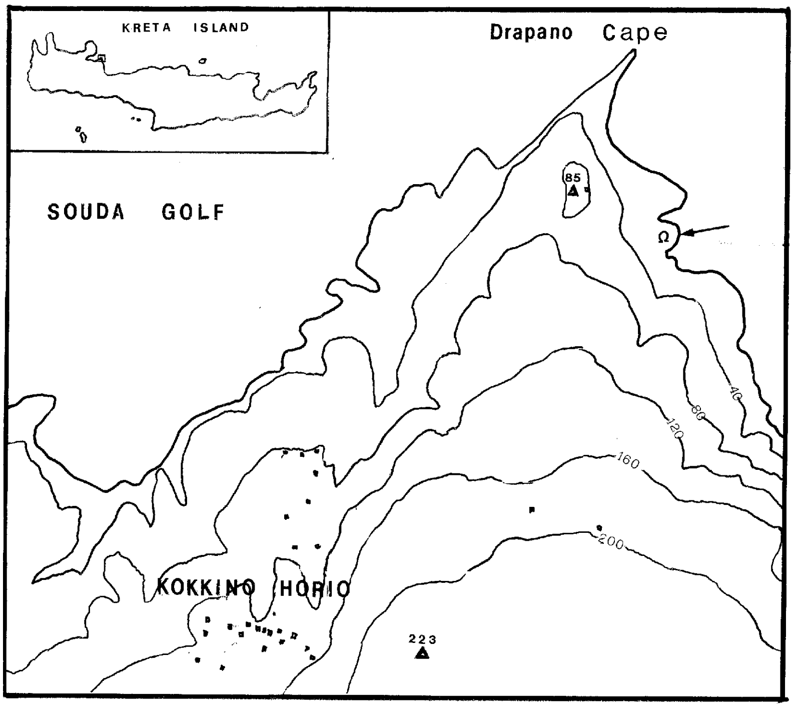

Fig.1 - Map of Crete. The arrow points to the fossiliferous cave.

Fig.2 - The main room of Vamos cave.

After the first publication, the diver and geologist V. Giannopoulos continued from time to time to collect and observe the elephants of Vamos cave. New fossils bones came to light and a new period for bone collecting is planned for the summer of 2001. Biometrical investigation of the new material clearly shows that we are dealing with the new endemic form previously described.

Fig.3 - Long bones of elephants still in the sea bed in Vamos cave.

3. DISCUSSION AND CONCLUSIONS

It was obvious from the beginning that these elephants had roamed the Chania area during the last climatic minimum, 18,000 y. BP. Possibly they had migrated there earlier during the episode of lower sea level. It was also clear that the elephants or their bones could only have entered the cave at periods when the sea level was at least 10-20 meters lower than today. This could alternatively have occurred shortly before the last marine transgression, a hypothesis making it possible that their extinction occurred at the beginning of Holocene. Questions similar to those concerning the history and the extinction of the Tilos elephants are apparent:

- When did these elephants arrived on Crete?

- What is their relation with the other Cretan species?

- What was the influence of Man and Nature on their extinction ? We must not forget that the Tilos elephants, the last European elephants, became extinct just less than 4000 y. BP (Theodorou 1986, and references within).

4. REFERENCES

Accordi, B. 1972. Lo scavo della “Grotta Simonelli” con cervi mani del Quaternario effettuato a Creta nel 1971 etc. *Accad. Naz. Lincei* 167: 1-17.

Ambrosetti, P. 1968. The Pleistocene dwarf elephands of Spinagallo (Siracusa, South - Eastern Sicily). *Geologica Romana* 7: 227-398.

Bate, D.M.A. 1907. On Elephant Remains from Crete, with Description of *Elephas creticus* sp.n. *Proc. zool. Soc. London. 1907*: 238-250.

Kuss, S.E. 1965. Eine pleistozane Saugetierfauna der Insel Kreta. *Ber. Naturf. Ges Freiburg i. Br*. 5: 265-304.

Kuss, S.E. 1966. Beitrage zur Pleistozan - Fauna der Insel Kreta - I. Die von D. Bate 1904 gesammelten Elefanten - und Cerviden - Reste - *Naturf. Ges. Freiburg i. Br.* 56: 169-181.

Kuss, S.E. 1970. Abfolge nud Alter der Pleistozanen Sangetierfannen der Insel Kreta. *Naturf. Ges. Freiburg i. Br.* 60: 35-81.

Melendis, J. 1960. Studien uber fossible Vertebraten Griechenlands. I. Ein Beitrag zur Kenntnis der Verbreitung von *Elephas (archidiskodon)* meridionalis arhaicus Dépèeret & Mayet, 1923, *Ann. Geol. Pays Hell.* 11: 266-284. Athens.

Melentis, J. 1961. Studien uber fossible Verterater Criechenlands 2. Die Dentition der pleistozanen Proboscidier des Beckens von Megalopolis im Peloponnes (Griechenland). *Ann. Geol. Pays Hell.* 12: 153-262.

Melentis, J. 1963. Studien uber fossile Vertebraten Griechenlands. 3. Die Osteologie der Pleistozanen Proboscidier des Beckens von Megalopolis im Peloponnes (Griechenland). *Ann. Geol. Pays Hell.* 14: 1-107.

Osborn, H.F. 1942. *Proboscidea Vol. 2: Stegodontoider, Elephantoidea*: 805-1675, figs. 681-1244. New York: The American Museum Press.

Reese, D. 1996. *Pleistocene and Holocene Fauna of Crete and its first Settlers*. Prehistory Press.

Sondaar, P.Y. & Boekschotten, G.J. 1967. Quaternary Mammals in the South Aegean Island Arc, with Notes on the other Fossil Mammals from the coastal Regions of the Mediterranean I/II. - *Konikl Nederl. Akad. Netensch Amsterdam*, B. 70(5): 556-576.

Symeonidis, N. & Theodorou, G. 1982. New findings of fossil elephants on Crete Island. *Ann. Geol. d. Pays Hell.* 31, 113-129.

Theodorou, G. 1986. Pleistocene Elephants from Crete (Greece). *Modern Geology* 10: 235-242.

Vos De, J. 1979. The Endemic Pleistocene Deer of. Crete. *Proc. Konikl. Nederl. Akad. van Wetensch.*, B 82(1): 59-90.

Vos De, J. 1983. The Endemic Pleistocene Deer of Crete. *Verh. der Kon. Ned. Akad. van Wetenschopen, Af. d Naturkunde Eerte Reeks* 31.

The World of Elephants - International Congress, Rome 2001

The excavations of the last ten years at Charkadio cave on Tilos Island, Dodekanese, Greece

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SUMMARY: The excavations at Charkadio cave on the island of Tilos have brought to light a very rich fauna of endemic fossil dwarf elephants. The excavations, by the Department of Historical Geology and Palaeontology of University of Athens, started in 1971 and continue until today (Symeonides 1972, Bachmayer *et al.* 1976, 1984, Theodorou 1983, 1984, 1988, Theodorou *et al.* 1997). Recent excavations (July 2000 and July 2001) revealed for first time significant dwarf elephant skeletal remains, such as anterior and posterior legs and vertebrae from different juvenile and adult animals in anatomical position. The findings are presented to the public at the Town Hall of Megalo Chorio on Tilos Island.

1. INTRODUCTION

The purpose of this short presentation is to summarize available knowledge on the Tilos elephants, and to briefly mention some of the latest results on their taphonomy from the analysis of hundreds of drawings and pictures taken at different depths and sites in the cave (Theodorou, in prep). During the first 10 years, our efforts were aimed at gathering information on the stratigraphy, from the surface of the sediment up to a depth of 8.5 meters. Slowly it became clear that in order to answer some crucial questions about the cave fauna, research should give special emphasis to the detailed taphonomy. The extinction event of the elephants had to be correlated with Late Quaternary climatic events, volcanic activity or the possible co-occurrence of man and elephant on the Island during the Holocene. We had to deal with absolute dating, fossilization and taphonomy. The occurence of newly born, juvenile, adult and aged animals had to be explained. Morphological and biometrical studies produced significant information (Theodorou 1983) and allowed the recognition of two size groups belonging to males and females. The lack of complete skeletons, significant articulated parts, a complete vertebral column or significant cranial remains prevented us until now from giving a complete presentation and description of the elephants, and provisionally the name "*Palaeoloxodon antiquus falconeri*" was used, though it was clear (Theodorou 1983) that there was no direct contact between the populations of different Mediterranean Islands. We also had to answer some important questions. If deposition of the bones in the sediment was natural, could it be correlated with a catastrophic event, or did humans introduce the fossil bones while residing in the cave? Did people use the elephants for food? Did they transfer elephant body parts into the cave after killing the animals in the open? Did people arrive on the island before or after the extinction of the elephants?

2. EXCAVATIONS OF THE LAST DECADE

During the last 10 years we have begun to collect data that could give answers to the above-mentioned questions. We changed our way of working. Instead of digging deeper, we started to uncover large surfaces, good for taphonomical studies. To do this we had to face many serious technical problems, some still unsolved. Most of the sediment surface of the first cave chamber is covered by rocks col-

Fig.1 - Fossil bones of dwarf elephants at Charkadio cave on Tilos Island. Some of the long bones were found articulated in anatomical position (© G. Theodorou, Excavation July 2000).

lapsed from the roof. The fallen rocks make a layer which in some places is thicker than 1.3 m. Below the collapsed rocks we were lucky enough to uncover after 25 years of excavations fragmented skull remains, that are still being prepared with extreme difficulty. We still lack a skull with both tusks in the alveoli. Slowly during the last 5 years a substantial excavation surface has become available, and provided us for first time with significant taphonomical information documented in hundreds of drawings.

3. Discussion and Conclusions

The taphonomical study allowed us in July 2000 and July 2001 to document the existence of articulated long bones, vertebrae in natural sequence, carpal and tarsal bones etc., all *in situ*. The excavations also revealed also for first time (July 2000) inclined fossiliferous layers dipping toward the southeastern corner of the cave. Skeletal remains have been used for DNA analysis (Poulakakis, in prep.) revealing a relationship to recent Asiatic elephants. Separate studies carried out on the fossilization (Theodorou *et al.* 1985, Stathopoulou 2000) and studies on the micromorphology of tusks and bones (Theodorou *et al,* in prep.) have allowed us better to understand the morphology and evolution of the Tilos elephants, the last European elephants. These studies make up the database necessary to allow the study of elephant remains

Fig.2 - One of the very rare cranial remains of the dwarf elephants of Tilos, belonging to a very young animal. It has been restored from more than 190 fragments. (Max. length 29 cm) (© G. Theodorou).

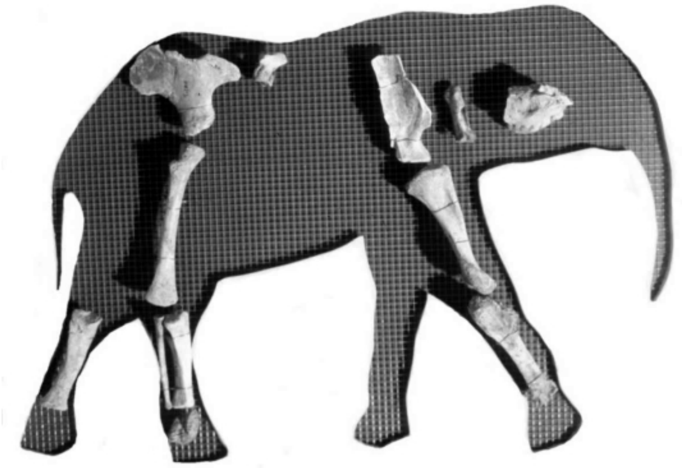

Fig.3 - Biometrical reconstruction of a juvenile skeleton (about 50x70 cm) in the exhibition room of the Town Hall at Megalo Chorio on Tilos Island. (© G. Theodorou).

found in archaeological collections all over Greece and especially on islands with endemic elephants. It is well known that all such remains are usually attributed to trade and not to the collection of fossils by Man. The relation of the Tilos elephants to Man is still unclear. The findings in anatomical position in layers that correspond to the last eustatic minimum cannot be correlated with human activity, making the problematic tusks fragments published long ago the only indication of Man in the cave.

4. PRESENTATION OF SCIENTIFIC RESULTS TO THE PUBLIC

An exhibition about the excavations opened in 1994 at the Town Hall of Tilos, and it will be soon transferred to a new building close to the cave that is being constructed. The small open-air summer theater, which was constructed by the Municipality of Tilos near Charkadio, and the asphalt road to the cave, have given a new dimension to the fossiliferous locality. All of these have allowed us to bring Vertebrate Palaeontology where it belongs: to the people of Greece and of Europe, who have to understand the very important environmental changes that occurred during Quaternary and the quality and fragility of the fossil treasures from our past that have to be studied, protected and preserved.

5. ACKNOWLEDGEMENTS

During each of the last 10 years excavations have been financed by the Ministry of the Aegean, and during the last 3 years they are co-financed by the General Secretary of Research and Technology at Athens. Our efforts to present to the public the results of our research programme have been strongly supported by the Major of Tilos, Mr. A. Aliferis.

6. REFERENCES

Bachmayer, Fr., Symeonidis, N., Seeman, R. & Zapfe, H. 1976. Die Ausgrabungen in der Zwergelefantenhohle “Charkadio” auf der Insel Tilos (Dodekanes, Griechenland) in der Jahren 1974 Und 1975. *Ann. Naturhistor. Mus. Wien*, 80: 113-144.

Bachmayer, Fr., Symeonidis, N. & Zapfe, H. 1984. Die Ausgrabungen in der Zwergelefantenhöhle der Insel Tilos (Dodekanes, Griechenland) im Jahr 1983, *Sitzung. der Österr. Akad. der Wissenschaften Mathem.-naturw. Kl.,* Abt. I., 193: 6-10.

Lampropoulou, G. 1999. Taphonomical Observations on the fossil material of excavation 1997, at the dwarf elephant cave Charkadio, on the Tilos Island (Dodekanese, Greece). *Unpublished Diplome Paper:* 1-100. UOA.

Michalopoulou, M. & Fasoulaki, M. 1998. Absolute dating by ESR in dental remains of *Palaeoloxodon antiquus falconeri*) from Charkadio Cave on Tilos Island (Dodekanese, Greece). *Unpublished Diplome Paper*: 1-97. UOA.

Stathopoulou, E. 2000. Study of the processes of fossilization and the interaction with the environment of Neogene and Quaternary vertebrate bones, *Unpublished MSC Thesis*: 207. UOA.

Stathopoulou, E. & Theodorou, G. 2001. Observations on the diagenesis of dwarf Elephant skeletal remains from the island of Tilos (Dodekanese, Greece). *This volume.*

Symeonidis, N.K. 1972. Die entdeckung von Zwergelefanten inder Höhle “Charkadio” auf der Insel Tilos (Dodekanes, Griechenland). *Ann. Geol. Pays Hell.,* 24: 445-461.

Symeonidis, N. &. Theodorou, G. 1997. The story of the last European Elephants. *Int. Ecological Congress. Peace, Environment, Culure and Tourism. Mediterranean 2000, Tilos Dodecanese, 14-21 Sept. 1997. Unesco, Tilos, Dodecanese*: 27-28.

Theodorou, G.E. 1987. Environmental factors affecting the evolution of island endemics. The Tilos Example. EUG IV,13-16 April 1987, Strasbourg. *Modern Geology,* 13: 183-188.

Theodorou, G. & Agiadi, K. 2001. Observations on fossil tusks from the Charkadio Cave (Tilos, Dodekanisa, Greece) under optical and scanning Electron Microscope. *This volume.*

Theodorou, G.E. 1983. The dwarf elephants of the Charkadio cave on the island of Tilos (Dodekanese, Greece), *PHD, Dissertation*: 1-231. UOA (In Greek).

Theodorou, G. 1983/4. Die Fossilen Zwergelefanten der Höhle Charkadio auf der Insel Tilos (Dodekanes, Griechenland). *Österreichische Akad. der Wissenschaften, Math.-natur-wissenschaftliche Kl. Anzeiger,* 120: 83-85.

Theodorou, G.E. 1985. On the occurrence of normal size pleistocene elephants on Crete island. EUG III, 1-4, April 1985, Strasbourg. *Terra Cognita,* 5 (2-3): SH15.

Theodorou, G.E. 1988. Environmental Factors Affecting The Evolution Of Island Endemics: The Tilos Example From Greece. *Modern Geology*, 13: 183-188.

Theodorou, G.E., Bassiakos, J.E. &

Papadopoulos, N.N. 1986. Uranium microdistribution in vertebrate skeletal remains from Caenozoic localities in Greece. *Int. Symposium on Archaeometry. 19-23 May 1986, Abstract Volume*: 184. *Archaeometry. Proc. of the 25th Int. Symposium*. 1989: 75-85.

Theodorou, G.E., Karistineos, N.K. & Papadopoulos, N.N. 1985/6. Uranium in fossil Caenozoic Vertebrates from Greece. *Ann. Geol. Pays Hell.* 33/1: 39-49.

Populations of woolly mammoth in North-East Siberia – dwarfing in isolation or last stage of extinction?

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At the end of the Pleistocene the range of woolly mammoth in Eurasia became dissected into isolated populations. Some of these were in Europe but the largest, as probably the case for other Pleistocene ungulates, existed in the north of Siberia. On Wrangel Island and the Taimyr peninsula, they crossed the boundary into the Holocene, surviving into the Holocene global warming.

The description of a "dwarf" race of mammoth from Wrangel Island raised questions about the reasons for dwarfing in this population. At the same time some mammoth remains from the latest Pleistocene (Berelekh, Sevsk and others) are of much smaller size than is usual for the Late Pleistocene woolly mammoth.

Our study of postcranial bones and recent finds of Holocene teeth on Wrangel, of normal size, show that the Holocene population of mammoth on the island included animals whose size is comparable to other mammoths from the Pleistocene-Holocene boundary in Eurasia. Nevertheless a representative set of molars, as well as tusks and some limb bones from Wrangel, are of "dwarf" size. So it is appears that animals of normal size coexisted on the island with others of almost dwarf size, and moreover that the latter are predominant by quantity of finds. Wrangel Island was fully isolated from 8000 years BP, and the mammoth population survived on this small (for this species) island for at least 4500 years. During this period the process of dwarfing started, but rapid changes of climate, and decreasing food, prevented the animals from becoming real dwarfs.

On the mainland, the latest isolated populations had more space so this provided no reason for dwarfing there. However, in the collections of mammoth bones from localities in North-East Siberia (Yana-Indigirka Lowland and the region to the east of the Kolyma River), some bones and teeth are of comparable size to the Wrangel "dwarfs". These specimens form up to 7-8 % of the collections as a whole.

"Dwarfs" are also famous from more ancient deposits throughout Eurasia. The explanation of this phenomenon may be aided by comparison with the individual variability of elephants. Among recent elephants in Africa and Asia, smaller-sized individuals or populations can be found, and in one case these have described as a separate species or subspecies (the forest elephants west and central Africa). Woolly mammoths on the mainland of Siberia became extinct without dwarfing, but in the last populations the size of the animals was much smaller than in previous times.

Finally we can say that only one refugium of woolly mammoth in the North-East of Siberia - Wrangel Island - had a population with signs of dwarfing. All other regions, including those adjacent to island territories, had a population of animals of normal size which, however, became generally smaller during the last stage of extinction.

Comparative observations on fossil tusks from three Quaternary Greek localities using scanning electron microscopy

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SUMMARY: The structure of Proboscidean tusks, from the Quaternary Greek localities of Tilos (45 ka BP up to 4-3.5 ka BP), Aliveri (Pleistocene), and Vlachioti (Lower Pleistocene), are compared on the basis of the dentinal tubule density and the tubule maximum diameter. In addition observations are made on sections perpendicular to the long axis of the tusk, with special concern to the preservability of the specimens. Although the taphonomic conditions play a very important role in this respect, a correlation also seems to exist between the above measurements and the degree of permeability and preservability of tusks. In addition, the values measured exhibit a reverse correlation with the tusk size. In fact the tusks of the dwarf elephants from Tilos, which are extremely brittle, have the largest density and tubule diameter.

1. Scope, material and methodology

The scope of this study is to compare the microstructural features of tusk samples from three Quaternary Greek localities. The material examined includes fragments of several fossil tusks of the dwarf elephants from the island of Tilos (Dodekanese), dated between 45 ka BP up to 4-3.5 ka BP, fragments of three Pleistocene tusks from Aliveri (Euboia), and of one Lower Pleistocene tusk found in the area of Vlachioti (Lakonia, Peloponese).

The dentinal tubule density and tubule maximum diameter are measured on SEM microphotographs of the tusk fragments, obtained from stub samples. Also, qualitative X-ray microanalyses (EDS) are considered in conjunction with the structural characteristics, to reach conclusions regarding the permeability and the preservability of the tusks.

The circumferential plane of a tusk reveals the perpendicular sections of the dentinal tubules. On this plane, measurements are taken of the dentinal tubule density and the tubules' maximum diameter. The dentinal tubule density is known to change depending on the distance from the pulp cavity. In fact, toward the outer surface of the tusk, the dentinal tubules branch, anastomose and fuse (Halstead 1974; Raubenheimer *et al.* 1998). Consequently, measuring the density of the tubules, at random distances from the pulp would not provide comparable results. To overcome this, all the measurements, in this study, are taken near the cementum – dentine junction (CDJ). The result is to observe only the outermost layer of dentine.

2. Observations

The tusks from Tilos had originally been attributed to *Palaeoloxodon antiquus falconeri* Busk (Symeonidis 1972). This name however refers to the dwarf elephants found on the island of Malta. Since no migration can been proved between the two islands, this name can not be used for the elephants of Tilos. Theodorou (1983) discusses this issue and temporarily accepts the use of the same name, until further material can be examined (Theodorou & Symeonidis 2001).

The specimens examined include large fragments of several tusks. Measurements of length and diameter of these tusks could not be taken.

At several points along the long axis of the tusk, and at a distance of about 4.5 mm from the periphery (CDJ), stubs were created to examine the circumferential and perpendicular plane. The mean dentinal tubule density of these specimens measures at 33,203 dt/sq mm (dentinal tubules per square millimeter), with a range from 21,200 dt/sq mm to 45,500 dt/sq mm. Also the mean dentinal tubule maximum diameter is 2.5 µm.

The SEM backscatter images of the sections perpendicular to the long axis of the tusk reveal alternate dark and light bands (Figs. 1 and 2). Microprobe analysis shows that, in the areas,

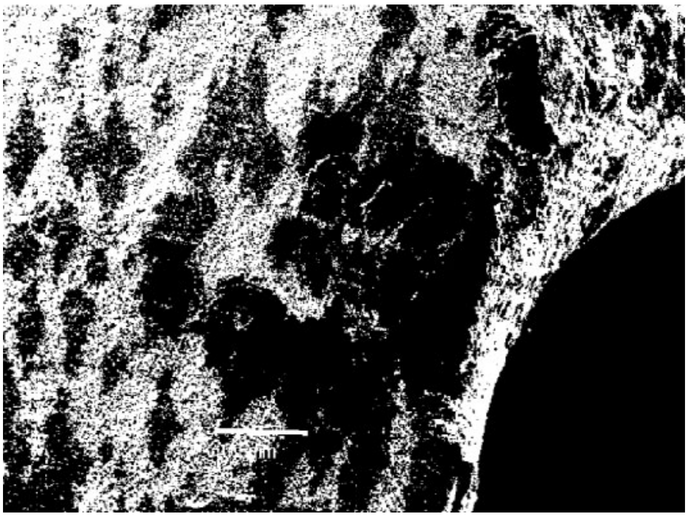

Fig.1 - SEM image of a perpendicular section of a tusk from Tilos. Morphologically there are no bands observed.

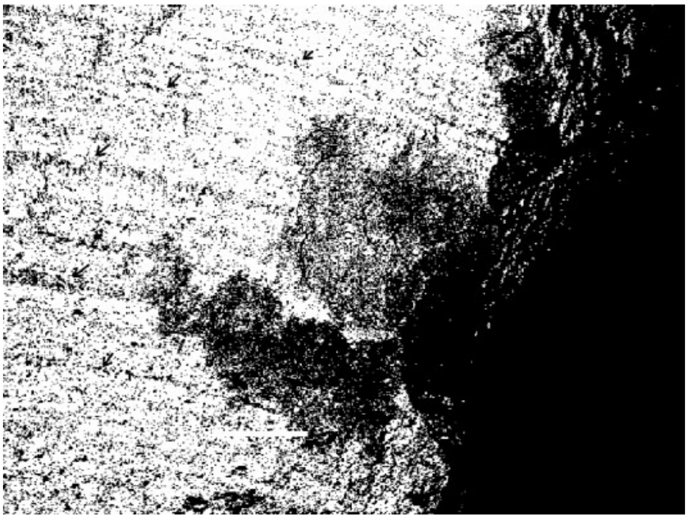

Fig.2 - SEM backscatter image of the same area as in fig. 1. The sample exhibits differences in the composition that are expressed as alterations of dark and light bands (arrow).

which appear dark, the dentine has formed porous spaces between the hydroxyapatite crystals, where the deposition of $CaCO_3$ has taken place.

The taxonomic position of the tusks from Aliveri (M. Dermitzakis & G. Theodorou – excavation 1977) is unknown. The Schreger pattern appears extremely faint. As a result, the Schreger angles could not be accurately measured, as to provide a diagnostic characteristic. The length and diameter of the specimen could only be measured on two of the tusks examined. Both of them are missing their tip and base. The length from proximal to distal end (arch) of the tusk 9/77/1 is 82 cm, while the same measurement for the tusk 9/77/2 is 100 cm. The maximum and minimum diameters in the middle of the tusk 9/77/1 are 11.32 cm and 10.15 cm respectively, while the same for the tusk 9/77/2 measure at 19.04 cm and 14.86 cm respectively.

The stub samples are taken from a distance of about 9 mm from the circumference, at the cementum – dentine junction, and from the middle part of the tusk. The mean dentinal tubule density is 23,177 dt/sq mm. This value ranges from 17,500 dt/sq mm to 25,500 dt/sq mm. The mean tubule maximum diameter is 1.2 μm. SEM microphotographs of the perpendicular plane again reveal an alteration of dark and light bands. However, in these samples, the dark areas correspond to actual porous spaces (deposition of $CaCO_3$ has not taken place) created as a result of the sinusoidal arrangement of the tubules (Fig. 3).

The Lower Pleistocene tusks from Vlachioti belong to *Mammuthus meridionalis* Nesti Originally they were attributed to *Archidiskodon meridionalis* by Symeonidis & Theodorou (1986), but the use of the name *Mammuthus* has been proved more appropriate (Shoshani & Tassy 1996). The tusk examined has a length of 110 cm from proximal to distal end (arch). The maximum and minimum diameters in the middle of the tusk are 11 cm and 8.5 cm respectively (Symeonidis & Theodorou 1986). The stub samples are taken from various points along the long axis of tusk, but from a distance of about 7mm from the periphery (CDJ). The mean dentinal tubule density is 32,236 dt/sq mm, with a range from 25,500 dt/sq mm to 43,000 dt/sq mm. The mean dentinal tubule maximum diameter is 1.5 μm (Fig. 4).

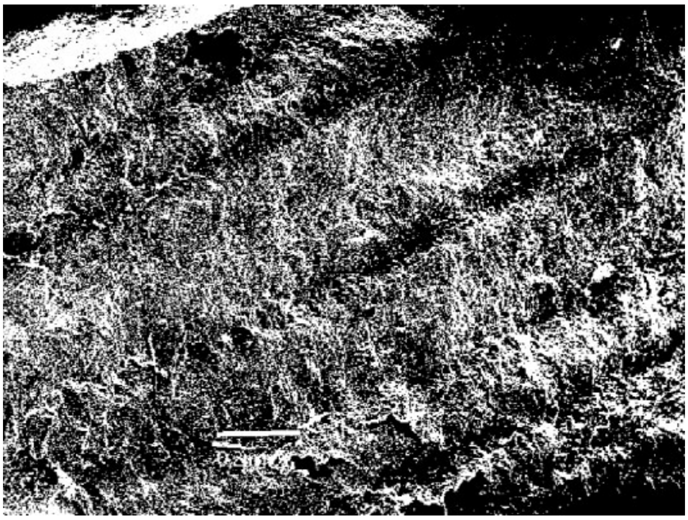

Fig.3 - SEM image of a sample from Aliveri. The alteration of dark and light bands are morphological. The dark bands (arrows) correspond to slanting of the dentinal tubules toward the circumference of the tusk.

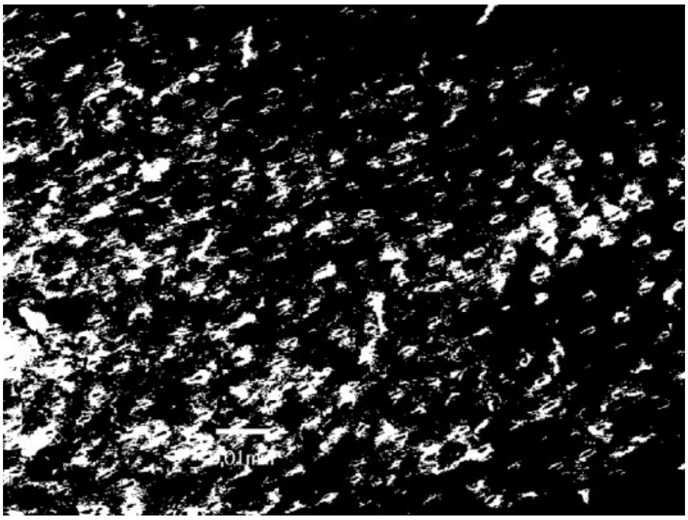

Fig.4 - Circumferential section of the tusk from Vlachioti.

3. DISCUSSION

According to results from measurements on tooth – dentine from other mammals (Forssell-Ahlberg *et al.* 1975) the diameter decreases with increasing distance from the pulp cavity. As a result the tusks of the dwarf elephants from Tilos would be expected to have the largest tubule diameter near the CDJ. Indeed, our measurements of the tubule maximum diameter show that the smaller tusks (Tilos) have the largest diameter. In order to compare samples we should therefore examine the variation of this value in the three dimensions, although the measurement near the CDJ can be useful, especially when dealing with fragments, since it could be indicative of the size of the tusk.

We observe that the Schreger pattern of alternating dark and light bands, interweaving to form a network, (Miles & Boyde 1961; Espinoza & Mann 1993; Fisher *et al.* 1998) is visible in all our specimens. However it is very easily discernible on the tusk from Vlachioti, less on the tusks from Tilos and very unclear on the tusks from Aliveri. According to Raubenheimer *et al.* (1998) the alternating light and dark bands, which macroscopically create the effect of the chequered pattern, are the result of the sinusoidal pattern of the dentinal tubules, as well as the differential compactness of the tubules between the light and dark bands. On the microphotographs of perpendicular sections from the tusks from Aliveri and Tilos the same image of alternating dark and light bands appears. In both cases the dark bands correspond to porous spaces resulting from this sinusoidal arrangement of the tubules. In the tusks from Tilos, these spaces have been filled with $CaCO_3$, while, in the tusks from Aliveri, deposition of $CaCO_3$ has not taken place. Raubenheimer *et al.* (1998) has shown that the number of dentinal tubules increases in the dark bands. As a result, the preferential deposition of $CaCO_3$ in the dark bands may be explained by the denser packing of the tubules in those areas. Indeed, the leaching out of the organic material, during the process of fossilization, would tend to create more empty spaces in the dark areas.

Macroscopically, the tusks from Aliveri appear hard and difficult to break. They have the lowest tubule density and tubule maximum diameter. The tusk from Vlachioti is also hard, but less than the specimens from Aliveri. It also has a small diameter, but a higher density. Finally the tusks from Tilos are extremely brittle and express preferential fissility along the dark zones, a lot more than the other samples. These have the highest values for diameter and density.

Comparing the tusks from Tilos to those from Aliveri, we observe that the permeation by environmental elements is exhibited only in the first case. Also the tusks from Tilos have higher values for tubule diameter and density, than the tusks from Aliveri. Consequently, the empty spaces created in the dark areas of the tusks from Tilos would be larger than on the tusks from Aliveri. Thus, it is expected that the permeability of the samples from Tilos would be greater.

4. CONCLUSION

The intensity of the Schreger Pattern, as it appears on fossil tusks, seems to depend on the permeability of the tissue. Salts are deposited in the areas, which, macroscopically and microscopically, appear dark, thus increasing the contrast between the dark and light bands. This preferential deposition in the dark bands seems to be due to the increased density of the dentinal tubules in those areas. However, deposition does not always take place, as in the case of the tusks from Aliveri.

The degree of permeation of a tissue by salt solutions depends on both the environmental conditions and the histology of the tissue itself. To this respect, the size and density of the dentinal tubules would partly control the deposition of salts in the tusk specimens, during the process of fossilization. Tusks that exhibit higher values for tubule density and diameter, under specific fossilization conditions, would tend to allow the deposition of salts, such as the $CaCO_3$, more than other specimens with lower density and tubule diameter. As a result, we should expect the preservation of the Schreger Pattern to be greater in those samples. Indeed, the macroscopic and microscopic observations made on the tusks examined in this study are indicative towards this hypothesis.

Concerning the preservability of the tusk specimens, this seems to correlate with the permeability of the samples. In fact, the tusks, in which the preferential deposition of salts has taken place, have the lowest degree of preservability. In addition, our observations indicate towards a reverse correlation between the dentinal tubule size and density and the degree of preservability of the tusk.

5. ACKNOWLEDGEMENTS

The Tilos research project has been financed by the Ministry of Aegean and the Greek General Secretariat for Reasearch and Techonology. For the completion of this study, which is a part of a larger project, examining the microstructure of fossil tusks from Greek localities, much is owed to Ass. Prof. G. Theodorou, as well as the members of the Vertebrate Palaeontology Team of the University of Athens.

6. REFERENCES

Bradford, E.W. 1967. Microanatomy and Histochemistry of Dentine. *Structural and chemical organization of teeth.* A.E.W. Miles. London, Academic Press. 2: 3-33.

Espinoza, E.O. & Mann, M.J. 1993. The history and significance of the Schreger Pattern in Proboscidean ivory characterization. *Journal of the American Institute for Conservation* 32: 241-248.

Fisher, D.C., Trapani, J., Shoshani, J., Woodford, M.S. 1998. Schreger angles in mammoth and mastodon tusk dentin. *Current research in the Pleistocene* 15: 105-107.

Forssell-Ahlberg, K., Brannstrom, M., Edwall, L. 1975. The diameter and number of dentinal tubules in rat, cat, dog, and monkey. *Acta Odont. Scand.* 33: 243-250.

Halstead, L.B. 1974. *Vertebrate Hard Tissues.* London: Wykeham Publications Ltd.

Miles, A.E.W. & Boyde, A. 1961. Observations on the structure of elephant ivory. *Journal of Anatomy* 95: 450.

Raubenheimer, E.J., Bosman, M.C., Vorster, R., Noffke, C.E. 1998. Histogenesis of the chequered pattern of ivory of the African elephant (Loxodonta africana). A*rchives of Oral Biology* 43: 969-977.

Shoshani, J. & Tassy, P. 1996. *The Proboscidea. Evolution and Palaeoecology of Elephants and their relatives.* Oxford, N.Y., Tokyo: Oxford University Press.

Stathopoulou, E. 2000. Study of the processes of fossilization and the interaction with the environment of Neogene and Quaternary vertebrate bones. *Unpublished MSc Thesis*, Athens University, 207 p.

Symeonidis, N.K. 1972. Die entdeckung von Zwergelefanten inder Hohle “Charkadio” auf der Insel Tilos (Dodekanes, Griechenland). *Annales Geologiques des Pays Helleniques* 24: 445-461.

Symeonidis, N.K. & Theodorou, G.E. 1986. On a new occurence of Lower Pleistocene Proboscidea in South Peloponnesse. *Annales Geologiques des Pays Helleniques* 33: 251-261.

Theodorou, G. 1983. The dwarf elephants of the Charkadio cave on the island of Tilos (Dodekanese, Greece). *PhD Thesis,* Athens University, 231 p.

Microwear analysis of *Mammuthus meridionalis* (Nesti, 1825) molar from Campo del Conte (Frosinone, Italy)

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SUMMARY: Tooth microwear caused by the abrasiveness of vegetables and especially the phytoliths of grasses has been studied by means of the SEM. A *Mammuthus meridionalis* molar from the Campo del Conte locality has shown the presence of specific wear patterns that appear to depend on the masticatory surface and mechanical masticatory forces. Scratches are more than pits and their number increases towards the tooth front. The microwear pattern of the *Mammuthus meridionalis* molar from Campo del Conte falls in the grazers domain, where scratches are more than pits, showing dietary adaptation rather rich also in graminacae or vegetables containing a rather large amount of phytolithes.

1. INTRODUCTION

The alimentary habits of large mammals can be deduced from the microwear tracks on tooth enamel examined under the Scanning Electron Microscope (SEM). Pioneering works by Resenberg (1978), Walker *et al.* (1978) and Tedford (1988) showed different wear patterns, related to different kinds of food and diet.

As pointed out by Solounias *et al.* (1988), in browsers the microwear tracks are represented by more pits and fewer scratches, while in grazers more scratches, fewer pits and scanty cross scratches are found. Mixed feeders, that alternate seasonally, regionally or occasionally their diet, have an average percentage of pits and scratches between browsers and grazers.

Basically, the differences of enamel microscopic scars depend on the abrasive power of various kinds of vegetation (especially on the different occurrences of phytoliths of grass) as well as on the direction of stress forces, necessary for food breakage, that are applied by masticatory muscles. Despite the large amount of studies on the elephant molars, the microwear analysis of enamel are still almost unknown (Palombo *et al.* 2000). Elephants exhibit a quite unusual manner of food comminution, depending on the wideness of masticator surface and on the high number of enamel bands of upper and lower molars, that meet together mesially in power stroke.

In order to evaluate the validity of microwear analysis on elephant molars, this study was conducted on several enamel points of one last molar. The sample used comes from a sedimentary sequence outcropping at Campo del Conte in the lower Sacco valley (Frosinone, southern Latium).

The sequence was deposited over a time span of approximately 1 Ma, in a predominantly fluvial environment. The basal terms can be ascribed to the Late Lower Pleistocene on the basis of the occurrence of a representative of *M. meridionalis* characterized by fairly advanced molar characters.

2. MATERIALS AND METHODS

A very well preserved *M. meridionalis* last upper molar was studied (Fig. 1). This specimen is made up of +16 laminae, of which 8-8.5 were in use. The morphological and biometrical characteristics of the specimens suggest an advanced specimen of *M. meridionalis.* (Palombo *et al.*, in press).

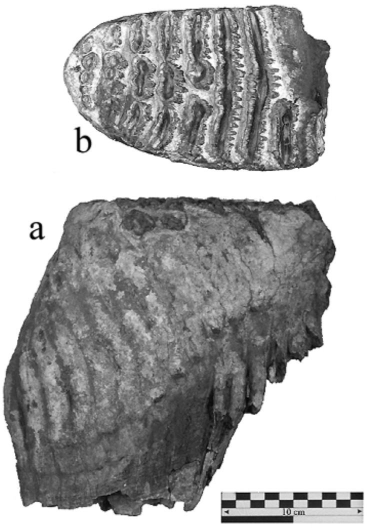


Fig.1 - *Mammuthus meridionalis* (Nesti 1825) from Campo del Conte, Early Pleistocene, M^3 in labial (a) and occlusal (b) view.

To obtain the casts for analysis, the enamel surface was first repeatedly washed with deionised water. After drying, each lamella was covered with vinyl polysiloxane impression material (Elite H-D Putty soft setting, Zhermack, Italy). The first mold was peeled off and discarded with the impurities that eventually were not removed by deionised water. The second mold was used in the microwear analysis with hydrophilic vinyl polysiloxane impression material (Elite H-D Super Light Fast Setting, Zhermack, Italy). Poliuretan casts were made from each mold using "Quartz Die" (Zhermack, Italy).

The casts were subsequently sputter-coated with gold and were examined with the SEM. Each lamella cast was individually studied. Photomicrographs were taken at ×25, ×200 (Figs. 2, 3) and ×500.

The length and width of each scar were recorded and analysed by means of the specific microwear image analysis software (version 4.0.) prepared by Ungar (2001). Since scars vary in length, the ratio of four to one (length to width) was used to subdivide the original number of scars into pits and scratches.

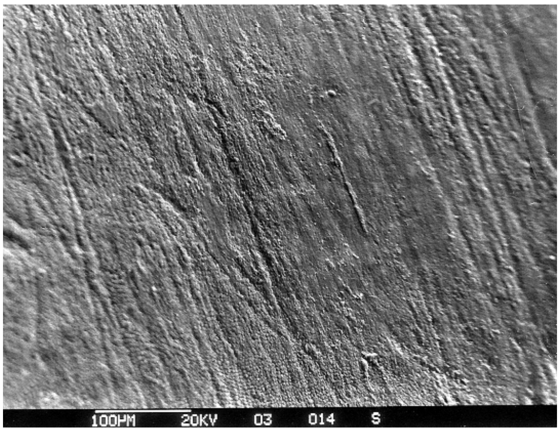


Fig.2 - Photomicrograph (× 200) of microwear on the 3rd lamina of M^3 from Campo del Conte.

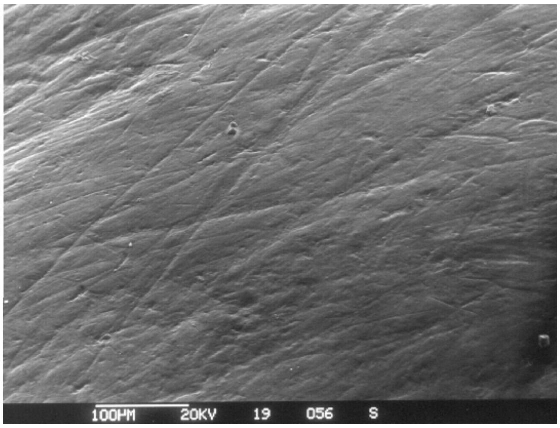


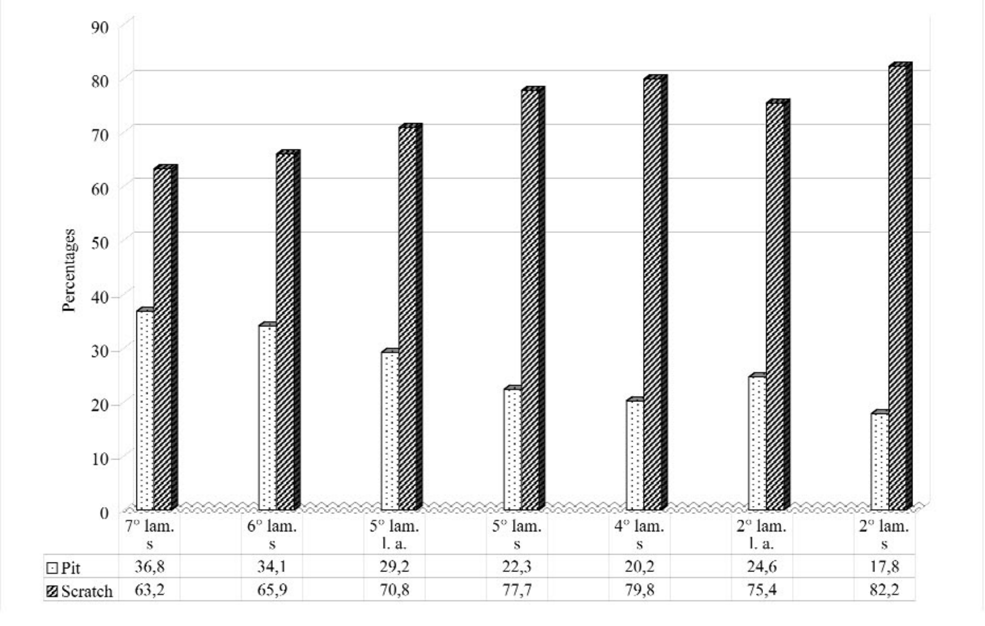
Fig.3 - Photomicrograph (×200) of microwear on the 6th lamina of M^3 from Campo del Conte.

Scars were categorized as pits if the ratio was less than four to one, and as scratches if the ratio was greater than four to one (Solounias & Moelleken 1992). For each photomicrograph, the average number of pits and scratches, percentages of pits and scratches were calculated.

3. RESULTS AND DISCUSSION

Several casts from anterior to posterior lamellae of the tooth were examined. The data for each photomicrograph (×200) can be summarized in percentages of pits and scratches. So, the range variation in the percentage of pits and scratches in relation to their position on the masticatory surface has been analysed. Moreover, for each photograph, the microwear features have been carefully studied.

From the percentage values of pits (average value = 26.4%) and scratches (average value = 73.6%), a clear predominance of the latter, starting from the posterior part with 63.2 % towards the 82.2 % in the anterior part can be clearly seen.



	7° lam. s	6° lam. s	5° lam. l. a.	5° lam. s	4° lam. s	2° lam. l. a.	2° lam. s
☐ Pit	36,8	34,1	29,2	22,3	20,2	24,6	17,8
▨ Scratch	63,2	65,9	70,8	77,7	79,8	75,4	82,2

Fig.4 - Istogram showing scratch and pit percentages from posterior to anterior M^3 occlusal surface.

At the same time, the percentage of scratches increases on the worner lamellae (Figs. 4, 5). This feature can be explained by considering stronger mechanical masticatory forces, in a transversal direction, applied on the anterior and middle part of the molar occlusal surface. Moreover, the scratches, everywhere considered on the masticatory surface, always prevail.

The study of the photomicrographs allowed the observation that the 3rd lamella, out of 8, shows, on its anterior occlusal surface (Fig. 2), a prevalently parallel patterns (still visible at ×500), even if there are also cross scratches on the upper occlusal surface; beside, it is also visible the prismatic structure of the enamel. On the 6/8 lamella (Fig. 3), in the anterior occlusal surface, deeper cross scratches of a rilevant lenght, along with shorter and lighter ones were observed. On this area of occlusal surface a parallel pattern of the scratches were not observed.

4. CONCLUSION

The microwear values of *Mammuthus meridionalis* molar from Campo del Conte fall in the grazers domain, where scratches are more than pits, showing a dietary adaptation, rather rich also in graminacee or vegetables containing a rather large amount of phytolithes. Moreover, it was observed that the scratches increase towards the tooth’s front. In elephants, differently from what was reported for other herbivores, the total number of cross scratches doesn’t seem important in order to identify their alimentary habits. The occurence of scanty cross scratches at major magnification seems to be consistent with this hypothesis.

5 ACKNOWLEDGMENTS

I wish to offer specials thanks to my teacher M.R. Palombo for the precious suggestions and

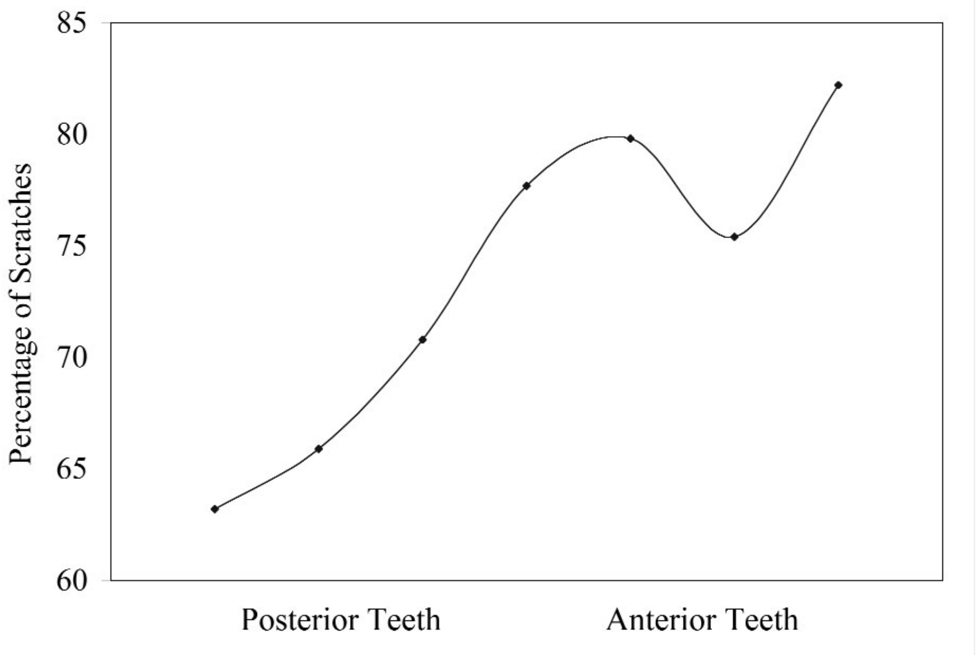


Fig.5 - Linear graphic showing scratch percentages from anterior to posterior M^3 occlusal surface.

the revision of the manuscript, and A. Mancini (CNR-CSQUEA, Roma) for the SEM photographs.

6. REFERENCES

Capozza, M., Palombo, M.R., Topa, T. 2000. Tooth microwear analysis of *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley, 1847 from Middle Pleistocene of Italy. Congress *“The Holoartic Ungulates of the Pliocene and Pleistocene”, 19-22 september 2000, Avignon. Abstracts*.

Palombo, M.R., Capozza, M., Topa, T. 2000. Analisi delle microtracce di usura nei molari dei proboscidati. *3° Congr. AIAZ, 2-6 November 2000, Siracusa, Abstracts*.

Palombo, M.R., Magri, D., Molinaro, A., Pisano, P. in press. The Pleistocene sequence of Campo del Conte (Lower Sacco Valley, Southern Latio). *Geologica Romana*.

Solounias, N. & Moelleken, S.M.C. 1992. Tooth microwear analysis of *Eotragus sansaniensis* (Mammalia: Ruminantia), one of the oldest know bovids. *Journ. Vert. Paleont.* 12 (1): 113-121.

Solounias, N., Teaford, M. & Walker A. 1988. Interpreting the diet of extinct ruminants. The case of a non-browsing giraffid. *Paleobiology* 40 (3): 287-300.

Tedford, M. 1988. A review of dental microwear and diet in modern mammals. *Scanning Microscopy*. 2: 1149-1166.

Ungar, P.S. 2001. *Microware software, Version 4.0. A semi-automated image analysis system for the quantification of dental microwear.* Unpublished, Fayetteville, USA.

Walker, A., Hoeck, H.N. & Pérez, L. 1978. Microwear of Mammalian Teeth as an Indicator of Diet. *Science* 201: 908-910.

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Isotope and microwear analyses on teeth of late Middle Pleistocene *Elephas antiquus* from the Rome area (La Polledrara, Casal de' Pazzi)

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SUMMARY: A multi-approach study was performed on molar teeth of late Middle Pleistocene *Elephas antiquus* from two sites in the Rome area (La Polledrara and Casal de' Pazzi). Different techniques, including SEM study of microwear tracks and stable isotope analyses (carbon, oxygen, and strontium) on tooth enamel, were applied in order to obtain independent information on paleodiet and crosscheck results.

Strontium isotope composition ($^{87}Sr/^{86}Sr$) helps to define the geographical area where the two populations were living, which is confirmed to be limited to the volcanic province of Latium. Carbon isotope measurements on structural carbonate of biogenic apatite (enamel) suggest a mainly C_3 diet for the two families, La Polledrara being characterised by slightly higher $\delta^{13}C$ values than Casal de' Pazzi. Preliminary oxygen isotope analyses on enamel phosphate suggest a possible influence of some diagenetic processes on the analysed material, indicating the importance of comparing results from different techniques in order to have a reliable reconstruction, not biased by limits linked to one method. The microwear analysis highlights the need of a very large number of samples to reach reliable conclusions. Preliminary results are consistent with the hypothesis of prevalently browser to intermediate type of diet for late Middle-Pleistocene *Elephas antiquus* in the two sites, Casal de' Pazzi population having a slightly more accentuated grazing attitude. Carbon isotope results suggest drier condition for the La Polledrara population, comparing with Casal de' Pazzi population, which is consistent with published paleoenvironmental reconstruction for the Mediterranean area.

1. INTRODUCTION

The study of alimentary habits of extinct herbivorous gives valuable insights on paleovegetation, allowing paleoenvironmental reconstruction. Methods developed to carry on these researches are various; the most common is to study the isotope composition of vertebrates mineralised tissues, which reflect their diet. Isotopes on herbivorous provide information not only on isotope composition of environmental water and, indirectly, on climate (phosphate oxygen, Longinelli 1995), but also on prevalent diet and, therefore, on typical local vegetation (carbon on structural carbonate in bio-apatite, Cerling & Harris 1999). In fact, plants are devised in two broad groups characterised by different photosynthetic pathways (C_3 and C_4) having different $\delta^{13}C$ values ($\delta^{13}C$ mean value -27‰ and –12‰ respectively): most tree and shrubs use a C_3 photosynthetic pathway, whereas most grasses use the C_4 pathway. Moreover, strontium isotope geochemistry may yield environmental information on the substratum the studied animals where leaving on. Land animals assume their Sr isotope ratios from the underlying soils and bedrock: the comparison of the Sr isotope ratio measured in the mammal's skeletal remains with the ratios of the soils and bedrock where the fossils were found can be used to distinguish between resident and non-resident animals.

Microwear scars analysis on tooth enamel examined under the Scanning Electronic Microscope can also infer the diet-behaviour of exctant-exctint mammals. Pioneering studies focused on the relationships between dental microwears patterns and different kinds of feeding. Microwear analysis on extinct mammals teeth furnish indication on mean alimentary habits, averaging seasonal dietary changes, usually related to important changes in molar microwear patterns, and changes in individual microwear features, which have a very short turnover time (formation/obliteration) of wear patterns. Despite the large amount of studies on elephants, microwear analyses of elephant enamel remain almost unknown.

The aim of this work is to study the paleodiet of Italian Middle Pleistocene *Elephas antiquus* comparing results from different methods in order to test their reliability.

2. MATERIALS AND METHODS

The molars of *Elephas antiquus* have been chosen from fauna assemblages whose structure was widely investigated, and for which hypotheses on environmental conditions have been proposed (Caloi *et al.* 1998). Studied samples come from the late Middle-Pleistocene sites of La Polledrara di Cecanibbio (Torre in Pietra Faunal Unit, Oxygen Isotope Stage 9) and Casal de' Pazzi (Vitinia Faunal Unit, Oxygen Isotope Stage 7) (Anzidei *et al.* 1999; Gliozzi *et al.* 1997).

Enamel samples for isotope analyses were manually separated from the central part of molar M_3 teeth, mechanically cleaned from dentine using tungsten-carbide or diamond-impregnated rotary tools, and then finely ground with an agate mortar. Enamel powders for carbon and oxygen isotope analyses of structural carbonate of biogenic apatite were first reacted with NaOCl 2% for 24 h, followed by reaction with 0.1 M acetic acid for 3 days (Koch *et al.* 1997), then washed with distilled water and dried at 40°C. The resulting enamel powder was further checked under microscope binocular for possible contamination. 150-250 mg of powder were reacted with phosphoric acid in vacuum at 25°C for three days. The cryogenically separated CO_2 was analysed on a Finnigan MAT 252 mass spectrometer. Precision of duplicates of structural carbonate is ±0.1 ‰ (mean standard deviation 1σ) for carbon isotope composition, and ±0.2 ‰ for oxygen isotope composition. The protocol outlined in Crowson & Showers (1991) and Lécuyer *et al.* (1993) was used for oxygen isotope analysis in enamel phosphate. The Ag_3PO_4 crystals were reacted with BrF_5 at c. 600°C for 15h; the oxygen obtained from the reaction was then converted to CO_2 by cycling over hot graphite in the presence of a Pt catalyst. The isotopic measurements were carried out by means of a Finnigan Delta S mass spectrometer. Standard deviation of measurements ranges from about ±0.1 to ±0.2 ‰ (1σ). Isotopic ratios are reported relative to the isotopic standard PDB-1 for C and V-SMOW for O using the conventional d notation:

$$\delta = (R_{sample}/R_{standard} - 1) \times 1000$$

To avoid the diagenetic Sr, which can modify the $^{87}Sr/^{86}Sr$ ratios, samples were pre-treated with 1,0 N acetic acid and then washed with bi-distilled water. 100 mg of sample were dissolved in 2.5 N HCl, and Sr chemical separations were performed using standard ion-exchange chromatographic methods. The measured ratios were fractionaction-corrected to an $^{86}Sr/^{88}Sr$ value of 0.1194. Repeated analyses of NBS 987 Sr standard gave average $^{87}Sr/^{86}Sr$ of 0.71024 +/- 2. Standard deviations are expressed as 2σ on the means.

Microwear analysis were first performed on each enamel loop of two well preserved last lower molar (M_3), from the two sites, as a test to verify the microwear variability. On the base of this test, following analyses were performed only on the averaged-worn laminae. Microwear analysis procedures are described in detail in Capozza (2001).

3. RESULTS

Strontium isotope composition for both La Polledrara and Casal de' Pazzi samples ranges between 0.70983-0.71008, falling within the compositional range of pyroclastic volcanic rocks of the Rome surrounding (0.70980-0,71050, Federico *et al.* 1994).

Figure 1A shows a box plot of carbon isotope composition of the analysed structural carbonates. Fourteen samples, seven per site, for a total of thirty measurements were performed. $\delta^{13}C$ isotope values for La Polledrara range between –10.8‰ and –9.7‰ with a median carbon isotope value of –10.6 ‰, whereas Casal de' Pazzi samples has a median $\delta^{13}C$ value of –11.9 ‰ (between –13.7 and –11.3 ‰). A reconstruction of *E. antiquus* paleodiet is suggested in Figure 1B, using the carbon isotope fractionation between diet and bioapatite as proposed by Cerling & Harris (1999). All analysed samples fall in the "C_3 dominated diet" field, although La Polledrara has a relatively ^{13}C-poorer diet than Casal de' Pazzi. Preliminary comparison between oxygen isotope ratios of structural carbonates and phosphates seems to indicate a possible influence of some diagenetic effects for carbonates (Iacumin *et al.* 1996) that need further investigation. For this reason oxygen isotope data are not be presented in this paper.

Molars from La Polledrara have scratches average values between 53.5 and 62.6 in percent (Fig. 2); mean scratch length is 200 µ ca. Scratches are generally thin, but long and deep tracks are also rarely presents. The molars from Casal de' Pazzi have scratches average values between 69.4 and 77.2 in percent (Fig. 2); they are close to each other, have a mean length ca 600 µ, and their trend is not always parallel. Two to three, sometimes up to four, different

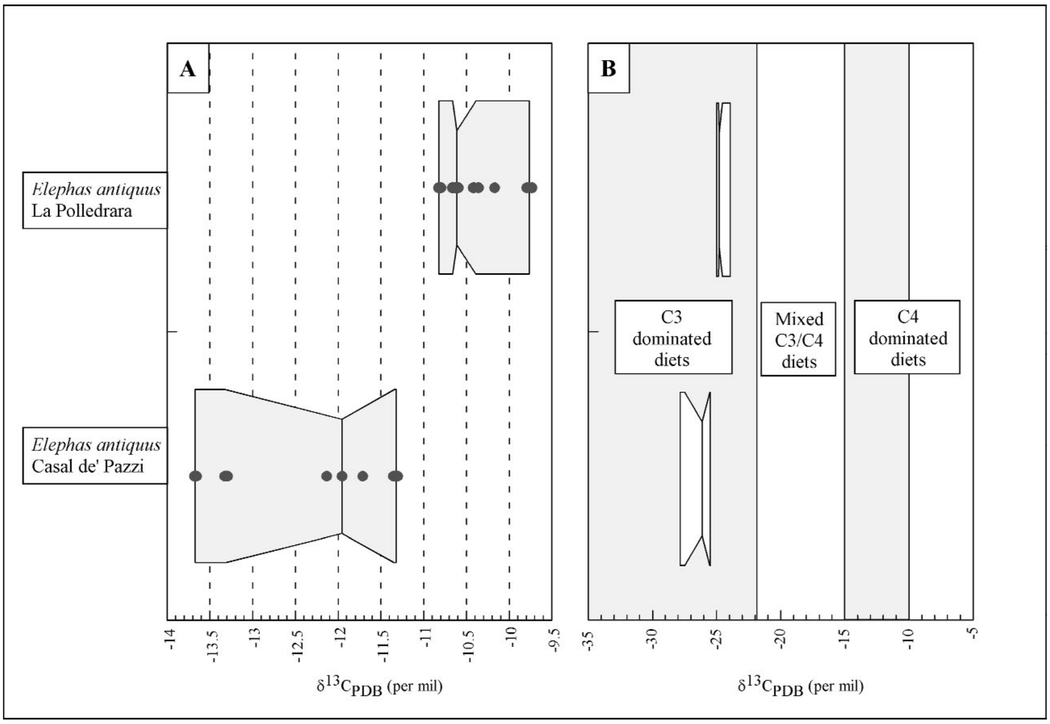

Fig.1 - A) Box plots of carbon isotope composition of analysed samples: dots represent each sample; the box contains all samples for each family; the notch represents the median value. B) Calculation of paleodiet for the two analysed family, following Cerling & Harris (1999).

generations of scratches are visible in the Casal de' Pazzi samples. Pits in both La Polledrara and Casal de' Pazzi samples are grouped and sometimes situated at the scratches cross. Mean microwear values of the averaged-worn laminae of the occlusal surface correspond to mean microwear values of the whole molar, allowing selecting the central part of the tooth for microwear analysis.

The variability ranges of the two molar samples used as test (molar 680 and molar 330) are distinct; average values of the other studied molars fall in these two distinct ranges, depending on the sites to which they belong.

Plotting the mean numbers of pits versus scratches, our *E. antiquus* specimens mainly fall in an area related to browsers and mixed feeders, as defined by Solounias & Moelleken (1992). The younger specimens from Casal de' Pazzi fall in the mixed feeders area, though some lie in a transition zone towards the grazer feeders field.

4. DISCUSSION AND CONCLUSIONS

Results assess the difficulty to establish the dietary adaptation of fossil elephants only on the basis of one method. Strontium isotope composition ($^{87}Sr/^{86}Sr$) helps to define the geographical area where the two populations were living, which is confirmed to be limited to the volcanic province of Latium. Carbon isotope measurements on structural carbonate of biogenic apatite (enamel) suggest a mainly C_3 diet for the two families, La Polledrara being characterised by slightly higher $\delta^{13}C$ values than Casal de' Pazzi. Preliminary results of oxygen isotope analyses on enamel phosphate suggest a possible influence of some diagenetic processes on the analysed material, which need

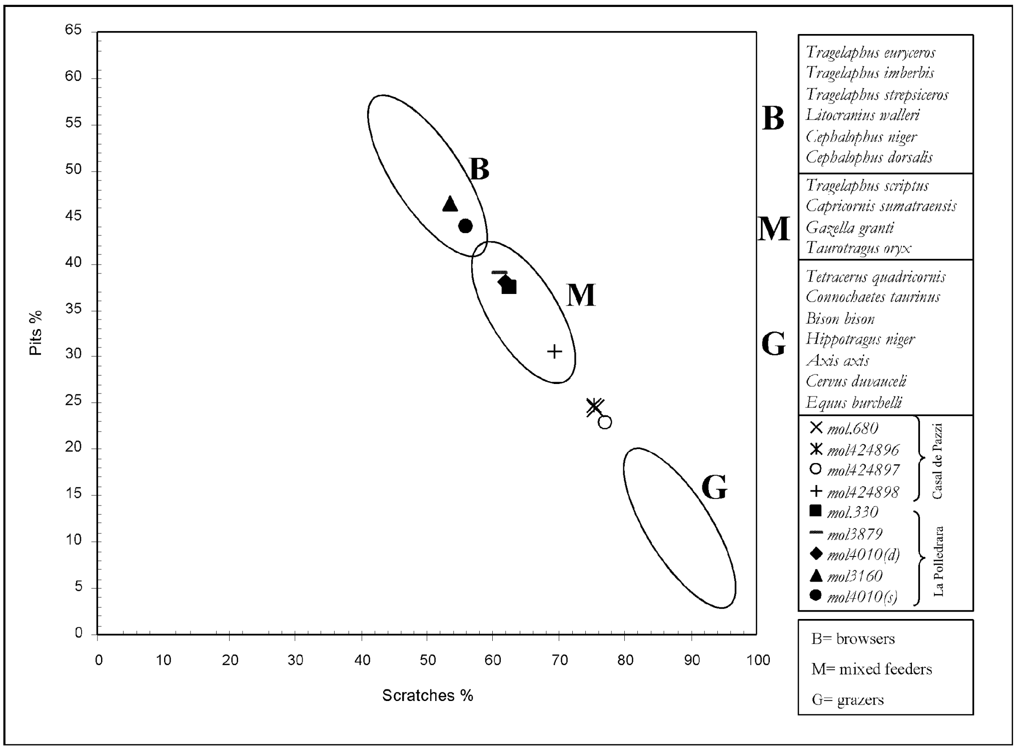

Fig.2 - Plot of microwear values of molars from La Polledrara and Casal de' Pazzi samples; diet subdivision are as proposed by Solounias & Moelleken (1992).

to be further investigated.

For what concern microwear tracks, reliable conclusions are possible only collecting a very large number of data; samples taken from the averaged-worn laminae of the occlusal surface seem to be the most representative of average microwear pattern of each molar. Microwear results fall in the variability field of mixed to grazer ruminants for Casal de' Pazzi, and browser to mixed feeders for La Polledrara.

Preliminary data resulting from our multidisciplinary study indicate interesting differences between the two analysed sites, consistent with the paleoclimatic reconstruction for the two interglacial periods (OIS 9 and 7, Vergnaud Grazzini *et al.* 1990) to which they belong. Late Middle-Pleistocene *Elephas antiquus* of Rome area had a prevalently browser/intermediate type of dietary adaptation. Microwear results suggest that the attitude to eat grass, graminaceous plants or vegetables containing a rather large amount of phytoliths increased in the Casal de' Pazzi group, which is attributed to the Oxygen Isotope stage 7, a more humid, maybe forested, interglacial climatic phase. This attitude of eating more grasses in humid period is also confirmed by research on living elephants (Eltringham 1992). The slightly enriched $\delta^{13}C$ values of La Polledrara are probably linked to the more arid climate of OIS 9, as C_3 plants tend to have higher carbon isotope composition in xeric climate (Cerling & Harris 1999).

5. ACKNOWLEDGEMENTS

The authors wish to thank Anna Paola Anzidei of "Soprinintendenza Archeologica di Roma" for the kind permission to study the material from La Polledrara di Cecanibbio and Casal de' Pazzi sites. Microwear analysis was performed using the Microwear 4.1 software, kindly provided by Prof. Peter Hungar.

6. REFERENCES

Anzidei, A.P., Arnoldus. Huizendeveld, A., Caloi, L., Palombo, M.R. & Lemorini, C. 1999. Two Middle Pleistocene sites near Rome (Italy): La Polledrara di Cecanibbio and Rebibbia-Casal De' Pazzi. *Monogr. Romisch-German. Zentralmuseum.* 42: 173-195.

Caloi, L., Palombo, M.R. & Zarlenga, F. 1998. Late-Middle Pleistocene mammal faunas of Latium (central Italy): stratigraphy and environment. *Quaternary International.* 47/48: 77-86.

Capozza, M. 2001. Microwear analysis of Mammuthus meridionalis (Nesti, 1825) molar from Campo del Conte (Frosinone, Italy). *This volume.*

Cerling, T.E. & Harris, J.M. 1999. Carbon isotope fractionation between diet and bioapatite in ungulate mammals and implications for ecological and paleoecological studies. *Oecologia*. 120: 347-363.

Crowson, R.A. & Showers, W.J. 1991. Preparation of phosphate samples for oxygen isotope analysis. *Anal. Chem.* 63: 2397-2400.

Eltringham, S.K. 1992. Ecology and Behavior. In J. Shoshani (eds.), *Elephants. Majestic cratures of the wild*: Sydney: Weldon Owen.

Federico, M., Peccerillo, A. & Barbieri, M. 1994. Mineralogical and geochemical study of granular xenoliths from the Alban Hills Volcano, central Italy; bearing on evolutionary processes in potassic magma chambers. *Contributions to Mineralogy and Petrology*. 115(4): 384-401.

Gliozzi, E., Abbazi, L., Ambrosetti, P., 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 in Italy. The state of the art. *Riv. It. Paleont. Stratigr.* 103(3): 369-388.

Iacumin, P., Bocherens, H., Mariotti, A. & Longinelli, A. 1996. Oxygen isotope analyses of co-existing carbonate and phosphate in biogenic apatite; a way to monitor diagenetic alteration of bone phosphate? *Earth and Planetary Science Letters.* 142(1-2): 1-6.

Koch, P.L., Tuross, N. & Fogel, M.L. 1997. The Effects of Sample tretment and Diagenesis on the Isotopic Integrity of Carbonate in Biogenic Hydroxylapatite. *Journal of Archaeological Science* 24: 417-429.

Lécuyer, C., Grandjean, P., O'Neil, J.R., Cappetta, H. & Martineau, F. 1993. Thermal excursions in the ocean at the Cretaceous-Tertiary boundary (northern Marocco): $\delta^{18}O$ record of phosphatic fish debris. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 105: 235-243.

Longinelli, A. 1995. Stable isotope ratios in phosphate from mammal bone and tooth as climatic indicators. In B. Frenzel (eds.), *Proceedings of the ESF Workshop*: 57-70. Bern 1993: Palaeoklimaforschung Bd 15, Special Issue.

Solounias, N. & Moelleken, S.M.C. 1992. Tooth microwear analysis of *Eotragus sansaniensis* (Mammalia: Ruminantia), one of the oldest know bovides. *Journ. of Vert. Paleont.* 12(1): 113-121.

Vergnaud Grazzini, C., Saliège, J.F., Urrutiaguer, M.J. & Iannace, A. 1990. Oxygen and carbon isotope stratigraphy of ODP Hole 653A and Site 654; the Pliocene-Pleistocene glacial history recorded in the Tyrrhenian Basin (West Mediterranean). In K.A. Kastens, J. Mascle, C. Auroux, E. Bonatti, C. Broglia *et al.* (eds.), *Proceedings of the Ocean Drilling Program*, *Scientific Results*: 107, 361-386. College Station, TX, United States: Texas A & M University, Ocean Drilling Program.

The World of Elephants - International Congress, Rome 2001

Discreteness of evolution and variability in mammoth lineage: method for group study

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SUMMARY: Crucially new information on of mammoth lineage development was obtained. Based on large paleontological material, authors created a pioneering multidimensional model of lineage structure. It illustrates discreteness of macro- and microevolutionary processes and considerable variability implying a powerful genetic potential of the group under study that have provided it with flexibility and predominance among the Quaternary faunas of Northern Eurasia. These important results were realised while studying the main morphometrical features last molars (M3) with the help of the authors' original approach based on building and analysing of multidimensional diagrams. The method allows to demonstrate visually and to analyse vast amounts of paleontological material in the context of populational studies. The model of the structure clearly demonstrates discreteness of evolutionary processes, polytypism and polymorphism of the taxa. It allows to trace ecological adaptations in the group, to define dynamics of stations, to carry out paleozoogeographical and paleoecological reconstructions.

1. INTRODUCTION*

Elephants of Archidiskodon-Mammuthus lineage are traditionally considered to be the main group in Quaternary paleontology and biostratigraphy. Permanent improvement of dental system and ability of wide migration conditioned relatively high evolution speed and wide adaptive radiation in geographically different and frequently changing paleoclimatic conditions. The transformations in dental system, easily traced from archaic to the latest forms, included: changes in teeth proportions, simplification of plate structure, increase of plate quantity and frequency in a crown, and decrease of plate length and enamel thickness. The most efficient processing of vegetation was achieved by the means of dental structures such as: enamel, cement, and dentine, as well as of specific construction of a tooth as a whole. Wide spreading of elephants on the vast territories of Eurasia and North America in Pliocene and Pleistocene caused the appearance of large variety of forms. The group systematics based partly on cranial morphology features and mainly on molar structure, is complicated and often confused, and taxonmical definitions are impeded by wide range of variability of the features mentioned. The method proposed allows to solve these problems and to obtain new information on group development during the Quaternary (Foronova & Zudin 1986, 1995, 1999).

2. MATERIAL AND METHOD

Over 2000 molars were studied. They belong to representatives of all the taxa known in the lineage originating from numerous localities of Northern Eurasia. The study was based on

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*This paper is largely based on the presentation given at the 1st Mammoth Conference in St. Petersburg in 1995, that was published as: Foronova, I.V. & Zudin, A.N. 1999. "The structure of the lineage *Archidiskodon-Mammuthus* in Eurasia and peculiarities of its evolution". In Haynes, G., Klimovicz, J. & Reumer, J.W.F. (eds.), Mammoths and the Mammoth Fauna: Studies of Extinct Ecosystem Deinsea 6: 103-118.
It was included in this volume as it represent a completion of the arguments discussed by Foronova in this volume.

building of two-dimensional distribution in coordinates of plate frequency on a 100 mm stretch of crown length (average plate length is marked on a parallel scale) and enamel thickness. These features are traditionally regarded as the major ones for defining of taxonomic position of mammoth-lineage elephants. Proposed method for data processing and diagram-building is applied for the first time in Quaternary palaeontology. It permitted to derive a maximal amount of information from morphological features and to analyse vast complexes of material from the whole lineage and its regional variations.

The operating sequence of the method was the following: 1) Building of punctuated diffusion diagrams. 2) Converting "point clouds" into numeric values of distribution density, and simultaneous sliding averaging (replacing of a single square-platform to the half of its side). 3) Building of distribution density isolines and normalising of distribution density values in the units of the Law of Uniform Density (division of the sample volume by the variability range square). 4) Hierarchic procedures that imply varying of the sizes of averaging square-platform. With the help of this procedure we succeeded in revealing a range (0.8-1.0-1.5) in which the character of distribution did not depend on a building technique.

It was found that 30-50 specimens are enough for its stabilisation. While making samples, all types of variability except the intraspecific one were being excluded. Separate dia-

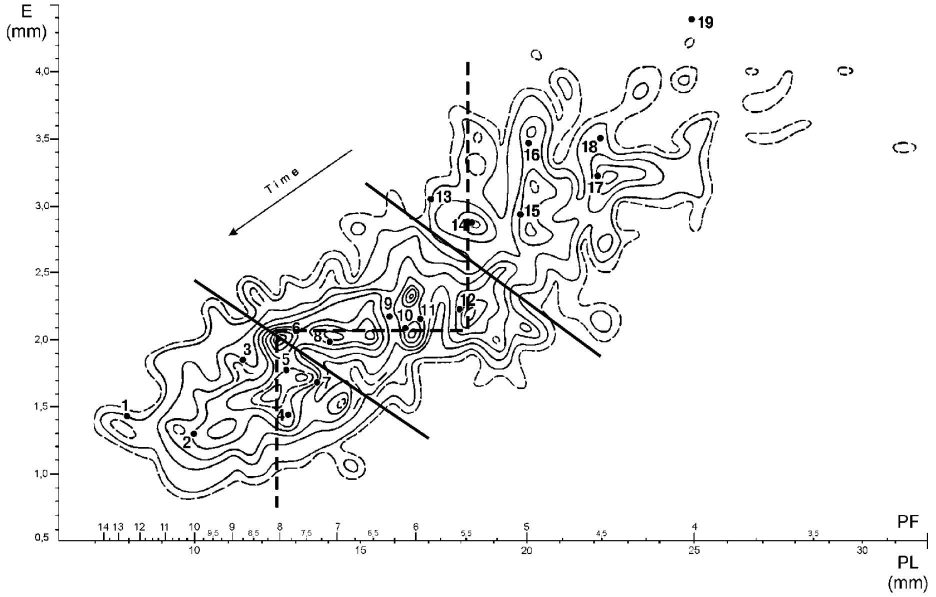

Fig.1 - Variability of the elephants of the Mammoth lineage in Europe (according to M3 parameters). Coordinate axis: E - enamel thickness; PF - plate frequency on 100 mm stretch; PL - length of one plate. Continuous isolines of distribution density are drawn through 0.5 Uniform Density Units, punctuated isolines are drawn through 0.25 Units, outer isoline corresponds to 0.25. Whole lines show the largest depressions (?taxonomical boundaries). Puncntuated lines show the assumed direction of lineage development due to selection pressure.

Points are the coordinates of typical specimens of taxa distinguished in the lineage and some peculiar forms: 1. *Mammuthus primigenius sibiricus*; 2. *M. primigenius primigenius*, neotype; 3. *M. primigenius jatzkovi*, holotype; 4. *M. primigenius fraasi*, holotype; 5. *M. primigenius*, early form, average parameter values; 6. *M. primigenius* (Chokurcha site); 7. *M. primigenius*, lectotype; 8. *M. intermedius*, holotype; 9. *M. trogontherii chosaricus*, holotype; 10. *M. trogontherii chosaricus*, holotype (authors' measurements); 11. *M. trogontherii trogontherii*, lectotype; 12. *A. trogontherii* (Azov museum; authors' measurements) = *A. wüsti*; 13. *A. meridionalis cromerensis*, holotype; 14. *A. m. voigtstedtensis*, holotype; 15. *A. m. tamanensis*, holotype; 16. *A. meridionalis*; 17. *A. m. meridionalis*, holotype; 18. *A. gromovi*; 19. *A. m. taribanensis*.

grams were built for Europe, Western and Eastern Siberia. They appeared to be extremely informative and clearly demonstrated the lineage structure to be far more complex than a traditional gradualistic sequence still in use.

3. RESULTS AND DISCUSSION

Generally, the variability area (from archaic forms to the latest mammoth) reflects canalising selection in the lineage due to global natural changes of the Quaternary (Fig. 1). However, the most important and innovative result is that selection of combinations of the features under study (i.e. of levels of dental system specialisation, most optimal for different stages of lineage development) was observed to be discrete. The structure consists of subordinated "adaptive peaks" (zones of high distribution density) and depressions, and resembles "Wright's symbolic picture" (in terminology of Dobzhansky 1951). The peaks group into ensembles, so an hierarchy of marginal depressions can be seen. One of the large ensembles corresponds to the final stage of lineage development within the genus *Mammuthus*. In addition to adaptive peaks of axial zone, we pioneered to find series of peaks in "thick-enamel" and "thin-enamel" areas of distribution. They are oppositely oriented and clinally linked with the axial zone peaks. These peaks are entirely new elements, significantly differing the structure from traditional gradualistic model. Thick-enamel peaks are represented by the forms with thickened folded enamel, medial sinuses, and low hypsodonty of a crown, whereas high hypsodonty, rare narrow plates with thin and weakly folded enamel are typical of thin-enamel forms.

Adaptive peaks are regarded as stages of phenotype stabilisation (or as phenotypes), their definite positions in the lineage allowing to correlate them with elementary evolving structures-populations. Non-consistency of intrapopulational variability was observed both in heterochronous and isochronous populations (samples from some archaeological sites, as well as samples of contemporary African and Asian elephants). Predominance of one (sometimes two) phenotypes in these populations permits to use molars for evolution studies, but also shows the possibility of making mistakes while working with small samples or single specimens. The fact that the structure is multiconed implies populational variability in the lineage (polymorphism) and polytypism of taxa. Parameters of typical specimens of some taxa correspond to optimums of adaptive peaks.

Comparison of regional diagrams shows transcontinental penetration of the majority of phenotypes and chiefly autochthonous speciation almost within entire station. Slight difference between the parameters of analogous phenotypes from various regions implies geographical clinal variability due to different responses of regional environments to global climatic changes. Thick-enamel and thin-enamel adaptive peaks are regarded as forms with different ecological adaptaion. Many facts -morphofunctional differences, accompanying fauna and flora, different stations, physical dates, and certain agreement between the sequence of these forms and the stages of oxygene-isotope Ocean scale-provide grounds to link thick-enamel and thin-enamel adaptations with interglacial and periglacial environments respectively. Different stations are serious argument in favour of paleoecological specialisation of mammoths. The station of the elephants with thin-enamel phenotypes lied in a relatively narrow transcontinental zone (approx. $^1/_3$ of *M. primigenius* sensu lato maximal station). The forms with thick-enamel and axial phenotypes were spread considerably wider. Their stations overlaped the previous one and covered the territory of former glaciers.

Apparently, thin-enamel forms, which can be traced all the way through the lineage, played a special role. It was them that could pioneer new adaptive zones, since chiefly thin-enamel phenotype was being selected during the evolution. Figure shows several moments of abrupt decrease of enamel thickness before depressions-possible taxonomical boundaries within the lineage. The first of such events can be seen before a generic border (points 13, 14, 12) on the stage of late archidiskodonts (1.0-0.8 Ma BP approx.). The second one is before a border between the “early” and “late” forms of *M. primigenius* (points 6, 5, 4), on the stage of the early one (0.16 Ma BP approx.). It is remarkable that it is these mammoths that are characterised by the maximal plate quantity in the lineage (30). These boundaries are remarkable by their outstanding paleogeographical events, which probably caused two large waves of station expansions: first, to the middle latitudes of Eurasia, and then to the extremely high ones.

REFERENCES

Dobzhansky, T. 1951. *Genetics and the origin of species.* New York: Columbia University Press.

Foronova, I.V. & Zudin, A.N. 1986. A new approach to the study of North Eurasian fossil elephants of the *Archidiskodon-Mammuthus* lineage. In S.A. Arkhipov (ed.), *Biostratigraphy and Paleoclimates of Pleistocene in Siberia*: 6-31. Novosibirsk. (In Russian).

Foronova, I.V. & Zudin, A.N. 1999. The structure of the lineage *Archidiskodon-Mammuthus* in Eurasia and peculiarities of its evolution. In G. Haynes, J. Klimovicz & J.W.F. Reumer (eds.), *Mammoths and the Mammoth Fauna: Studies of Extinct Ecosystem* - Deinsea 6: 103-118.

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Phylogenetic position of *Elephas, Loxodonta* and *Mammuthus*, based on molecular evidence

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SUMMARY: Previous authors have disagreed about the phylogenetic relationships between *Mammuthus*, *Elephas* and *Loxodonta*. Phylogenies based on the mitochondrial cytochrome b gene were contradictive. We sequenced a 450 base pair fragment of the mitochondrial control region. A phylogenetic tree based on 76 parsimony informative characters shows a well supported sister group relationship of *Mammuthus* with *Elephas*, whereas *Loxodonta* retains a basal position.

1. INTRODUCTION

The three main genera of Elephantidae, *Elephas, Loxodonta* and *Mammuthus*, originated during the Pliocene from the African genus *Primelephas* (Maglio 1973). *Elephas* and *Mammuthus* migrated to Eurasia and became extinct in Africa, where only *Loxodonta* persisted.

The question which of the two living genera of elephantids, *Elephas* or *Loxodonta*, is closer to *Mammuthus* phylogenetically, or whether *Mammuthus* branched off from the common stem first, is a simple three-taxon problem. However, despite a number of efforts, this problem has presented considerable resistance to being solved.

As *Elephas* and *Mammuthus* share a relatively derived molar structure, they were traditionally grouped together (Shoshani *et al.* 1985). In another morphological character, the shape of the tip of the trunk, *Mammuthus* is more similar to *Loxodonta* (Vereshagin & Tikhonov 1990).

Well preserved mammoth remains from the Siberian permafrost soil do not only allow the reconstruction of soft tissue anatomy like trunk shape, but also extraction of intact pieces of macromolecules. Therefore in recent years, several teams have begun sequencing fragments of mammoth DNA, preferably mitochondrial DNA, which is present in multiple copies in each living cell and has a good chance of being preserved many years after death. Table 1 gives an overview of these studies and their differing results. It is noteworthy that, even when the same genes were sequenced (cytochrome b in most cases), the results were strikingly different: Ozawa *et al.* (1997) identified a monophyletic group *Elephas-Mammuthus*, whereas Noro *et al.* (1998), using more or less the same fragment but different individuals, found a clade *Loxodonta-Mammuthus*. Both groups reported a good bootstrap support for their results, but suffered from low number of individuals analysed (one or two mammoth samples only). Recently, we re-analysed the data of Ozawa *et al.*, but used our own new *Loxodonta* sequence for comparison (Hauf *et al.* 2000), which resulted in an association *Elephas-Loxodonta*, whereas *Mammuthus* occupied a more basal position.

Thus cytochrome b appears to support either of the three alternative groupings, depending on the particular sequences used for comparison and possibly also on the particular region of this gene chosen (see Joger *et al.* in press). We therefore decided to sequence a non-coding mitochondrial region, the control region (d-loop) in order to have an independent indicator for phylogenetic relationships.

Tab.1 - Attempts to determine the phylogenetic position of *Mammuthus* within the Elephantidae using mitochondrial DNA sequences.

Year	**Authors**	**No of sequenced base pairs**	**Gene**	**Results: sister groups**
1994	Höss et al.	92	16s RNA	not resolved
1994	Hagelberg et al.	283	cytochrome b	uncertain (*Mammuthus-Loxodonta*?)
1995	Hauf et al.	115	cytochrome b	uncertain (*Mammuthus-Loxodonta*?)
1996	Yang et al.	228	cytochrome b	*Mammuthus-Elephas*
1997	Derenko et al.	331	cytochrome b	not resolved
1997	Ozawa et al.	1005	cytochrome b	*Mammuthus-Elephas*
1998	Noro et al.	1137	cytochrome b	*Mammuthus-Loxodonta*
		961	12s RNA	*Mammuthus Loxodonta*
1999	Hauf et al.	335	cytochrome b	*Mammuthus-Elephas*
1999	Barriel et al.	varying	cytochrome b	uncertain *(Mammuthus-Loxodonta*?)
2000	Thomas et al.	545	cytochrome b	uncertain (*Mammuthus-Loxodonta*?)
2000	Hauf et al.	1005	cytochrome b	uncertain (*Elephas-Loxodonta*?)

2. MATERIALS AND METHODS

Bones of eight mammoth individuals from Wrangel island, Chukotka (NE Siberia) were used as sources of DNA. These bones belong to the subspecies *Mammuthus primigenius vrangeliensis* Garrutt, Averianov & Vartanyan 1993, which survived well into the Holocene (Vartanyan *et al.* 1995). Radiocarbon datings were done for two of our individuals from Wrangel (DM 13: 4250 BP, DM 5a: 5280 BP). Blood samples from five specimens of *Elephas maximus* were obtained from German zoos (origins: Vietnam, Thailand and Myanmar). The sequence of *Loxodonta africana* obtained earlier (Hauf *et al.* 2000) was used for comparison. A short nuclear insertion of a d-loop fragment discovered by Greenwood *et al.* (1998) in Asian elephants was also included in the analysis. *Dugong dugong* was used as outgroup.

Total DNA was extracted from the mammoth bone samples (or elephant blood samples). To avoid contamination by extraneous DNA, the bone surface was removed using a hand grinder. A 8 mm Ø perforation was made into the bone to obtain about half a gram of clean powdered sample. DNA was prepared by a silica-based purification method using the GENECLEAN® Kit (BIO 101, Inc., La Jolla, USA). The primers to amplify a fragment of 450 base pairs of the mitochondrial control region were chosen from the known mitochondrial sequence of *Loxodonta africana* (Hauf *et al.* 2000). The DNA amplification was performed in a reaction volume of 50 µl containing 1x PCR buffer (Qiagen), 2.5 mM $MgCl_2$, 150 µM dNTPs, 1.6 mg/ml BSA (MBI Fermentas), 0.5 mM of each primer and 1.25 units of *Taq* polymerase (Qiagen) in a Perkin Elmer Thermocycler (GeneAmp® PCR System 9700). The amplification conditions were: 95°C for 2 minutes for initial denaturation, followed by 40 cycles consisting of 94°C for 10 seconds, 54°C for 10 seconds 71°C for 40 seconds, followed by 72°C for 5 minutes for a final extension. No amplification was detected by electrophoresis in extraction and PCR blanks.

PCR fragments were sequenced in both directions according to the chain-termination method of Sanger *et al.* (1977), using the cycle sequencing technique. The sequencing reactions contained approximately 300 ng of amplified DNA as sequencing template and 5 pmol of the respective primer. To this mixture the appropriate amount of Big Dye® Terminator Cycle Sequencing Ready Reaction Sequencing Mix (PE Applied Biosystems, Weiterstadt, Germany) was added, following the manufacturer's instructions. The cycling conditions were: the denaturation step at 96°C for 10 seconds, followed by the annealing step at 50°C for 5 seconds and the extension/termination step at 60°C for 4 minutes, total of 25 cycles. The sequencing samples were electrophoresed on a ABI PRISM® 377 DNA sequencer and analyzed using the ABI PRISM™ Sequencing Analysis software, version 3.2 (PE Applied Biosystems, Weiterstadt, Germany).

Sequences were compared with the GeneDoc program, version 2.5.000. Trees (maximum parsimony and neighbor joining algorithms without weighting) were reconstructed with PAUP version 4.0.

3. Results and Discussion

Of the 450 base pairs of the mitochondrial d-loop sequenced, 76 were parsimony informative.

Neighbor Joining (Fig. 1) and Maximum Parsimony reconstructions revealed identical branching patterns which were statistically confirmed by 1000 bootstrap replicates. *Mammuthus* turned out as sister genus of *Elephas*, thus confirming the classical, morphologically based concept, whereas *Loxodonta* remained well outside the *Mammuthus-Elephas* clade. The short nuclear insertion sequence from Elephas took a position at the base of the *Mammuthus* lineage, thus providing additional evidence of a common ancestor of these two genera. We therefore conclude that current evidence is in favour of a sister group relationship of *Elephas* and *Mammuthus*. However, additional genes (especially nuclear genes) should be sequenced before definite conclusions can be drawn.

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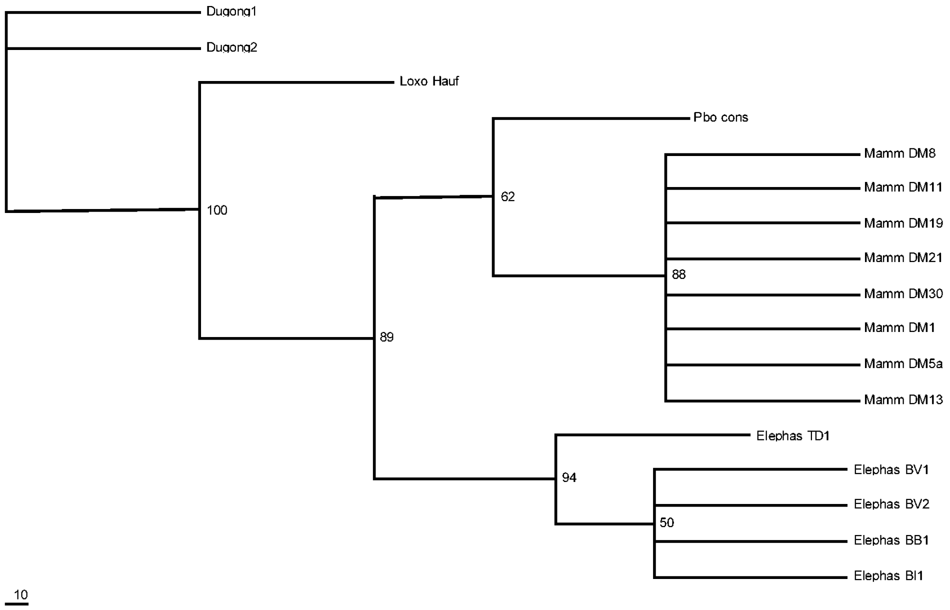

Fig.1 - Maximum paresimony tree of a 450 base pair sequence of the mitochondrial d-loop region of eight individual *Mammuthus primigenius vrangeliensis* (Mamm), five individual *Elephas maximus* and one *Loxodonta africana* (Loxo Hauf), including a short nuclear insertion from *Elephas* (Pbo cons, from Greenwood *et al.* 1998). Numbers indicate percent bootstrap values of 1000 replicates. The tree was rooted using the outgroup *Dugong dugong*.

5. REFERENCES

Barriel, V., Thuet, E. & Tassy, P. 1999. Molecular phylogeny of Elephantidae. Extreme divergence of the extant forest African elephant. *C.R. Acad. Sci. Paris* 322: 447-454.

Derenko, M., Malyarchuk, B. & Shields, G. F. 1997. Mitochondrial cytochrome b sequence from a 33,000 year-old Woolly Mammoth (*Mammuthus primigenius*). *Ancient Biomolecules* 1: 149-153.

Greenwood, A.D. & Pääbo, S. 1998. Nuclear insertion sequences of mitochondrial DNA predominate in hair but not in blood of elephants. *Molecular Ecology* 7: 1-5.

Hagelberg, E., Thomas, M.G., Cook, C.E. Jr., Sher, A.V., Baryshnikov, G.F. & Lister, A.M. 1994. DNA from ancient mammoth bones. *Nature* 370: 333-334.

Hauf, J., Bauer, A., Chalwatzis, N., Joger, U., Zimmermann, F. K. & Lazarev, P. 1995. Selective amplification of a mammoth mitochondrial cytochrome b fragment using an elephant-specific primer. *Current Genetics* 27: 486-487.

Hauf, J., Joger, U., Zimmermann, F.K., Lazarev, P. & Vartanyan, S.L. 1999. Protein and Nucleic acid sequences of Woolly Mammoth cytochrome b and the phylogenetic position of *Mammuthus* within the Elephantidae. In: G. Haynes, J. Klimowicz, & W. Reumer (eds.), *Mammoths and the Mammoths Fauna: Proceedings of the First International Mammoth Conference, St. Petersburg, Russia.* Deinsea (suppl.) 6: 211-217. Rotterdam.

Hauf, J., Chalwatzis, N., Joger, U. & Zimmermann, F.K. 2000. The complete mitochondrial genome sequence of the African elephant (*Loxodonta africana*) and its implication for the assessment of the systematic position of the Proboscidea. *Zoology* 102: 184-195.

Joger, U., Garrido, G., Hauf, J., Tikhonov, A. & Vartanyan, S. (in press). Genetic investigations on mammoth (*Mammuthus primigenius*). Deinsea.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.*, n.s., 63: 1-149.

Noro, N., Masuda, R., Dubrovo, I.A., Yoshida, M.C. & Kato, M. 1998. Molecular phylogenetic inference of the woolly mammoth *Mammuthus primigenius*, based on complete sequences of mitochondrial cytochrome b and 12s ribosomal RNA. *J. Mol. Evol.* 46: 314-326.

Ozawa, T., Hayashi, S. & Mikhelson, V.M. 1997. Phylogenetic position of mammoth and Steller’s sea cow within Tethytheria demonstrated by mitochondrial sequences. *J. Mol. Evol.* 44: 406-413.

Sanger, F., Nicklen, S. & Coulsen, A.R. 1977. DNA sequencing with chain terminating inhibitors. *Proc. Nat. Acad. Sci. USA* 74: 5463-5467.

Shoshani, J., Walz, D. A., Goodman, M., Lowenstein, J. M. & Prychodko, W. 1985. Protein and anatomical evidence of the phyletic position of *Mammuthus primigenius* within the Elephantidae. *Acta Zool. Fennica* 170: 237-240.

Thomas, M.G., Hagelberg, E., Jones, H.W., Yang, Z. & Lister, A.M. 2000. Molecular and morphological evidence on the phylogeny of the Elephantidae. *Proc. R. Soc. Lond.* B 267 : 2493-2500.

Vartanyan, S.L., Arslanov, K.A., Tertychnaya, T.V. & Chernov, S.B. 1995. Radiocarbon dating evidence for mammoths on Wrangel Island, Arctic Ocean, until 2000 BC. *Radiocarbon* 37: 1-6.

Vereshagin, N. K. & Tikhonov, A. N. 1990. *The exterior of mammoth* (in Russian). Irkutsk.

Yang, H., Golenberg, E.M. & Shoshani, J. 1996. Phylogenetic resolution within the Elephantidae using fossil DNA sequence from the American mastodon (*Mammut americanum*) as an outgroup. *Proc. Nat. Acad. Sci. USA* 93: 1190-1194.

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Preliminary U-series results and dating of faunal remains from Castel di Guido, Italy

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SUMMARY: The first U-Th data measured from five *Bos* teeth (enamel, dentine, cement) and seven bone samples from Castel di Guido (units 4 and 5) are presented in this study. The uranium content measured from tooth and bone samples is particularly high. The U-Th apparent ages of bone and cement samples are more scattered than for enamel and dentine samples. The dates of the teeth (enamel, dentine) are the most coherent, ranging from 250 to 170 ka. This range of date is in agreement with the fact that the Castel di Guido palaeosurface is younger than the "Tufo rosso a scorie nere" eruptive event of the Sabatini Volcanic District. The U-Th data obtained there are preliminary and ESR method will be applied for comparison.

1. INTRODUCTION

The Castel di Guido open site is located in central Italy (Latium), an area with complex stratigraphic correlations. The site is characterized by the presence of a Lower Palaeolithic industry and of a rich vertebrate fauna (Radmilli & Boschian 1996). Artefacts like choppers, chopping-tools and handaxes have been made either on stone or on bone which is a great particularity of the site. The sediments consist of interbedded fluviatil, lacustrine and volcanic deposits with the main characteristic of a reworking. The main faunal species discovered in the palaeosurface (units 4 and 5) of the site are *Bos primigenius, Elephas antiquus, Equus caballus, Cervus elaphus*. Recently, Caloi *et al.* (1998) suggested that the faunal association there belongs to OIS 9 (0.303-0.339 Ma, SPECMAP, Imbrie *et al.* 1984). The units 4 and 5 have succeeded the Sabatino explosive products "Tufo rosso a scorie nere" (TRSN). The data of K-Ar method applied on volcanic rocks from the TRSN appear to date the eruptive event at 442 ± 7 ka (Evernden & Curtis 1965; Fornaseri 1985). Then, this unit should be correlated to OIS 12 (Imbrie *et al.* 1984). The purpose of the present paper is to present new radiometric data in order to contribute to the dating of the Castel di Guido palaeosurface. U-Th results are presented for four kinds of tissues (bone, enamel, dentine and cement) of mammalian remains excavated from the units 4 and 5. Our ESR analyses will be presented in a future paper.

2. SAMPLE AND METHOD

The enamel, dentine and cement were separated using a dentist drill from the M3 teeth of five *Bos* individuals (N°11479, 405, 3436, 6155, 7599). Only one tooth, N°11479, has no remaining cement on the outer surface of the enamel, the other ones had small quantities. Samples of bone were extracted from the most compact part of two mandibles and of five fragments (Fig. 1). Samples were reduced to powder in an agate mortar for analyses.

The U-Th method is based on the measurement of the activity ratio ^{230}Th/^{234}U using the exponential function of ^{230}Th ingrowth. The disequilibrium between ^{234}U and ^{238}U is measured and taken into account for calculation. An early uranium uptake (EU) is assumed with no initial ^{230}Th. We have measured the activity ratios of samples by alpha spectrometry (IPH, MNHN) using the same procedure as described in another paper (Michel *et al.* 2000).

RESULTS AND DISCUSSION

All activity ratios (^{234}U/^{238}U, ^{230}Th/^{234}U) and the U-Th corresponding apparent ages of faunal samples from the units 4 and 5, are presented in Table 1 and Figure 1. These first analyses revealed that the uranium content within samples is very high. The U content range is between 9 and 49 ppm for compact enamel samples and between 195 - 863 ppm for porous tissues as dentine, bone and cement. U contents in bone and cement are the highest (Fig.1). This degree of content is rarely reached in fossil apatites. Only, few papers related very high U content in these types of samples; as for example, the U contents of the fossil bones from Olduvai Gorge between about 4 and 820 ppm (Williams & Marlow 1987). The authors concluded that U can be taken up very early in the fossilization process and the amount of U depends on the redox potential of the depositional environment. At Notarchirico site, Rhodes & Grün (1999) found high uranium content for teeth (1.5-6.5 ppm for enamel; 132-271 ppm for dentine). At Castel di Guido, the U content range in dentine is about 10 to 30 times higher than in enamel as Grün & Taylor (1996) observed or as others studies shown. The uranium content of the surrounding sediment (units 4 and 5) measured by gamma spectrometry, is relatively high: about 4-8 ppm. The U-Th apparent ages are more scattered for bones than for other types of material (Tab. 1 and Fig. 1). The apparent dates range from about 200 to 350 ka. The U-Th age of dentine and enamel samples are the most interesting data for dating. As a matter of fact, the data are more consistent, ranging between 170 and 250 ka.

Tab.1 - U-Th data of bone and tooth samples from Castel di Guido palaeosurface (units 4 and 5).

Sample	Unit, Zone, N$_i$	*Sample N$_i$	U (ppm)	^{234}U/^{238}U	^{230}Th/^{232}Th	^{230}Th/^{234}U	U-Th age (ka)
Bone fragment	5, - , 10877	cast10877b	253.0	1.142 ± 0.007	> 1000	0.878 ± 0.011	208^{+9}_{-8}
Bone fragment	5, - , 10879	cast10879b	862.6	1.015 ± 0.004	> 1000	0.940 ± 0.014	297^{+30}_{-23}
Bone fragment	5, - , 10881	cast10881b	249.2	1.081 ± 0.006	> 1000	0.942 ± 0.012	276^{+18}_{-16}
Bos mandible	5, - , 11479	cast11479e	9.3	1.098 ± 0.027	> 1000	0.831 ± 0.021	183^{+15}_{-13}
with M$_3$		cast11479d	286.4	1.175 ± 0.009	> 1000	0.824 ± 0.013	174 ± 7
		cast11479b	422.5	1.048 ± 0.007	> 1000	0.868 ± 0.014	212^{+12}_{-11}
Bos M$_3$	4, N14, 405	cast405e	15.7	1.118 ± 0.018	> 1000	0.811 ± 0.019	171^{+11}_{-10}
		cast405d	239.2	1.186 ± 0.016	> 1000	0.912 ± 0.019	227^{+19}_{-16}
		cast405c	282.3	1.131 ± 0.010	> 1000	0.892 ± 0.015	219^{+13}_{-11}
Bone fragment	4, T17, 1679	cast1679b	606.1	1.043 ± 0.007	> 1000	0.974 ± 0.016	351^{+62}_{-39}
Bone fragment	4, Q11 , 2392	cast2392b	526.0	1.050 ± 0.004	> 1000	0.853 ± 0.010	201^{+8}_{-7}
Bos M^3	4, U36, 3436	cast3436e	12.1	1.099 ± 0.018	> 1000	0.883 ± 0.019	217^{+18}_{-15}
		cast3436d	251.4	1.195 ± 0.009	> 1000	0.819 ± 0.015	171^{+8}_{-7}
		cast3436c	281.5	1.172 ± 0.008	> 1000	0.917 ± 0.014	233^{+14}_{-12}
Bos mandible	4, ZS21, 6155	cast6155e	14.9	1.127 ± 0.015	> 1000	0.826 ± 0.017	178^{+10}_{-9}
with M$_3$		cast6155d	195.2	1.146 ± 0.011	> 1000	0.873 ± 0.018	196^{+12}_{-11}
		cast6155c	265.9	1.180 ± 0.012	> 1000	0.905 ± 0.017	223^{+15}_{-13}
		cast6155b	265.8	1.048 ± 0.007	> 1000	0.870 ± 0.013	214^{+12}_{-11}
Bos M$_3$	4, ZZ122,7599	cast7599e	49.0	1.146 ± 0.011	> 1000	0.911 ± 0.016	232^{+16}_{-14}
		cast7599d	427.3	1.095 ± 0.006	> 1000	0.920 ± 0.012	248^{+14}_{-13}
		cast7599c	549.5	1.043 ± 0.005	> 1000	0.928 ± 0.014	271^{+21}_{-18}

Counting error : 1 σ uncertainies due to counting statistics.

*b= bone, e = enamel, d = dentine, c = cement.

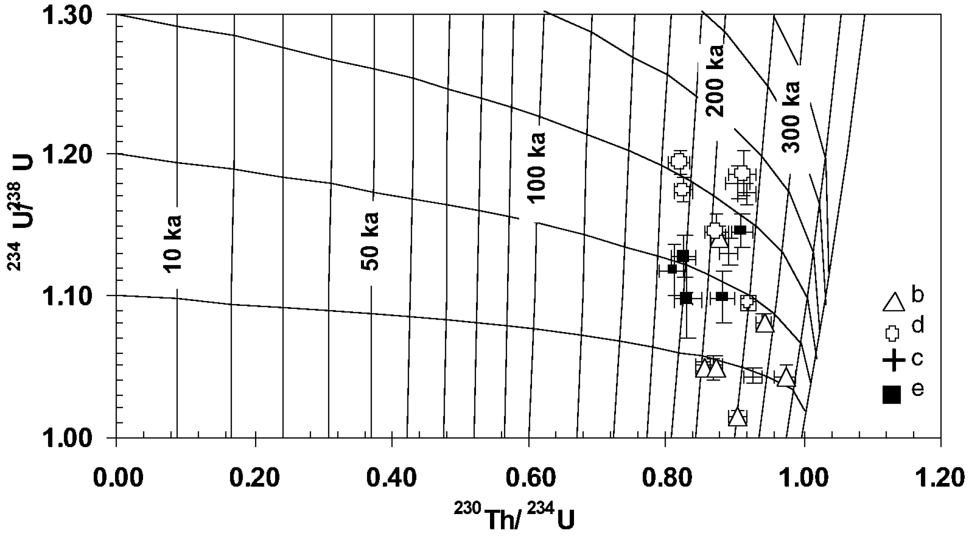

Fig.1 - The graphical solution of the U-Th age equation with variation of ^{234}U/^{238}U and ^{230}Th/^{234}U activity ratios of bone (b), dentine (d), cement (c) and enamel (e) samples from Castel di Guido site.

These first U-Th results will be compared with ESR data, by knowing by advance that the annual dose will be very different between the usual EU (early uptake) and LU (linear uptake) modes because of the high U content within the samples.

4. CONCLUSION

The first U-Th data of *Bos* teeth showed high uranium content and gave apparent U-Th ages ranging from 250 to 170 ka. These data are preliminary and will be compared to the ESR dating of the same teeth. Presently, the U-Th age range obtained on teeth is coherent with the fact that the age of the CDG palaeosurface is younger than the eruptive event (TRSN) of the Sabatini Volcanic District.

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6. REFERENCES

Caloi, L., Palombo, M.R. & Zarlenga, F. 1998. Late Middle Pleistocene mammal faunas of Latium (central Italy): stratigraphy and environment. *Quaternary International* 47/48: 77-86.

Edvernden, J.F. & Curtis, G.H. 1965. The Potassium-Argon Dating of Late Cenozoic Rocks in East Africa and Italy. *Current Anthropology* 6: 343-364.

Fornaseri, M. 1985. Geochronology of volcanic rocks from Latium (Italy). *Rendiconti della Società Italiana Mineralogia e Petrologia* 40: 73-105.

Grün, R. & Taylor, L. 1996. Uranium and thorium in the constituents of fossil teeth. *Ancient TL* 14: 21-25.

Imbrie, J., Hays, J.D., Martinson, D.J., McIntyre, A., Mix, A.C., Morley, J.J., Pisias, N.G., Prell, W.L. & Shackleton, N.J. 1984. The orbital theory of Pleistocene climate: support from a revised chronology of the marine δ^{18}O record. In A.L. Berger, J. Imbrie, J. Hays, G. Kukla & B. Saltzman (eds.), *Milankovitch and climate*: 269-305.

Dordrecht: D. Reidel Publishing Compagny.

Michel, V., Yokoyama, Y., Falguères, C. & Ivanovich, M. 2000. Problems Encountered in the U-Th Dating of Fossil Red Deer Jaws (Bone, Dentine, Enamel) from Lazaret Cave: a Comparative Study with Early Chronological Data. *Journal of Archaeological Science* 27: 327-340.

Radmilli, A.M. & Boschian, G. 1996. *Gli scavi a Castel di Guido, il più antico giacimento di cacciatore del Paleolitico inferiore nell'Agro Romano.* Firenze: Istituto Italiano di Preistoria e Protostoria.

Rhodes E.J. & Grün R. 1999. Preliminary ESR dates for tooth enamel from Notarchirico. In M. Piperno (ed.), *Notarchirico. Un sito Del Pleistocene Medio Iniziale nel Bacino di Venosa*: 245-251. Venosa: Osanna.

Williams, C.T. & Marlow, C.A. 1987. Uranium and thorium distributions in fossil bones from Olduvai Gorge, Tanzania and Kanam, Kenya. *Journal of Archaeological Science* 14: 297-309.

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Genetic data indicating that *Mammuthus primigenius* includes two species

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SUMMARY: The data on genetic differentiation within mammoths are considered in comparison with differentiation between extant elephants. Genetic differentiation within mammoths is high, they can be divided into two groups genetic, the distance between which is comparable to the distance between *Loxodonta africana* and *Elephas maximus*. This suggests the existence of two early diverging mammoth lineages, i.e., *Mammuthus primigenius* probably includes two twin species.

During the last years, the methods for amplification and sequencing of DNA fragments were applied to fossil remains and provided a means for comparative genetic studies on extinct and related living forms. In particular, successful PCR amplification and sequencing was performed for the following mitochondrial genes of mammoths and extant elephants: 93-base-pair (bp) fragment of the 16S ribosomal RNA gene (Hoss *et al.* 1994); 961 bp (complete sequence) of the 12S rRNA gene (Noro *et al.* 1998); and fragments of the cytochrome *b* gene of 242 bp, 277 bp (Hagelberg *et al.* 1994), 228 bp (Yang *et al.* 1996), 1005 bp (Ozawa *et al.* 1997) and complete sequence of 1137 bp (Noro *et al.* 1998). The main results of these studies were mutually contradictory. The researchers concluded that the results were unable to resolve conclusively the *Mammuthus-Loxodonta-Elephas* trichotomy (Hagelberg *et al.* 1994) or reported that they resolved the trichotomy in favour of closer relations between mammoths and the Asian elephants (Yang *et al.* 1996; Ozawa *et al.* 1997), or between mammoths and the African elephants (Noro 1998). However, a comparative analysis of all available genetic data (Dubrovo & Rautian 1999; Rautian & Dubrovo 2001) has shown that genetic distances *Mammuthus-Elephas, Mammuthus-Loxodonta* and *Loxodonta-Elephas* non-significantly differ from each other. Thus, mammoth is approximately equidistant from each living elephant. This suggests simultaneous divergence of the lineages of mammoth and living elephants from a common ancestral stock as a result of one and the same event of adaptive radiation. This conclusion agrees with the results of immunological studies (Lowenstein 1985) and comparisons of hair structure (Valente 1983); in these parameters, the distances between three elephantine genera were approximately equal to each other.

The purpose of this paper is a brief review of the data on genetic differentiation within mammoths in comparison with differentiation between extant elephants.

Relatively extensive material was obtained for the fragments of the cytochrome *b* gene examined independently by several research groups in six mammoths and a number of Asian and African elephants (Hagelberg *et al.* 1994; Yang *et al.* 1996; Ozawa *et al.* 1997; Noro *et al.* 1998). We combined the data from these papers and analysed the sequence of 218 bp (from base 96 to 282 and from base 289 to 319), available in each individual. The table shows pair-wise distances computed as the percentage of substitutions corrected by Kimura's two-parameter model (Kimura 1980). These data allow us to compare the differentiation within

Tab. 1 - Sequence distances among cytochrome b fragments of (M1-M6) *Mammuthus primigenius*, (L1-L6) *Loxodonta africana* and (E1-E6) *Elephas maximus*

	M1	M2	M3	M4	M5	M6	L1, 3,6	L2	L4	L5	E1	E2	E3, 4,5	E6
M1	0	5/0	4/0	6/1	6/1	4/0	4/1	4/1	3/1	4/2	6/0	9/0	6/0	10/0
M2	.024	0	1/0	9/1	9/1	1/0	7/1	7/1	8/1	7/2	7/0	10/0	7/0	11/0
M3	.019	.005	0	8/1	8/1	1/0	6/1	6/1	7/1	6/2	6/0	9/0	6/0	10/0
M4	.033	.048	.043	0	4/0	8/1	6/0	6/0	7/0	7/1	4/1	3/1	4/1	4/1
M5	.033	.048	.043	.019	0	8/1	4/0	4/0	5/0	5/1	4/1	5/1	4/1	6/1
M6	.019	.005	.005	.043	.043	0	6/1	6/1	7/1	6/2	6/0	9/0	6/0	10/0
L1,3,6	.023	.038	.033	.028	.019	.033	0	2/0	3/0	1/1	6/1	9/1	6/1	10/1
L2	.023	.038	.033	.028	.019	.033	.009	0	1/0	3/1	6/1	9/1	6/1	10/1
L4	.019	.043	.038	.033	.024	.038	.014	.005	0	4/1	7/1	10/1	7/1	11/1
L5	.028	.043	.038	.038	.028	.038	.009	.019	.023	0	6/2	9/2	6/2	10/2
E1	.028	.033	.028	.023	.023	.028	.033	.033	.038	.038	0	3/0	1/0	4/0
E2	.043	.048	.043	.019	.028	.043	.048	.048	.053	.053	.014	0	3/0	1/0
E3,4,5	.028	.033	.028	.023	.023	.028	.033	.033	.038	.038	.005	.014	0	4/0
E6	.048	.053	.048	.023	.033	.048	.053	.053	.058	.058	.019	.005	.019	0

The upper right matrix includes the number of transitions/number of transversions. The lower left matrix includes Kimura two-parameter distances.

Primary data on M1 and M2 were obtained by Hagelberg *et al.* (1994); M3, by Noro *et al.* (1998); M4 and M5, by Yang *et al.* (1996); M6, by Ozawa *et al.* (1997); L1-L4, by Noro *et al.* (1998); L5, by Irwin *et al.* (1991); L6, by Yang *et al.* (1996); E1-E4, by Noro *et al.* (1998); E5, by Hagelberg *et al.* (1994); E6, by Yang *et al.* (1996).

(L1,3,6) and (E3,4,5) designate three African and three Asian elephants possessing identical DNA sequences.

mammoths with those of extant elephants and with intergeneric differences.

The mean distances between the pairs *Mammuthus-Elephas*, *Mammuthus-Loxodonta* and *Loxodonta-Elephas* are 0.034, 0.032 and 0.044, respectively. These distances non-significantly differ from each other (Rautian & Dubrovo 2001). The mean values of intraspecies distances in *Mammuthus, Elephas* and *Loxodonta* are 0.029, 0.008 and 0.009, respectively. Thus, extant elephants show much lower individual variation than mammoths, whereas differentiation within the latter is comparable to intergeneric differentiation. This was not revealed by the authors of original data because they did not analyse combined primary data but compared their results with only the conclusions of earlier studies.

To create a graphic representation of relationships between considered individuals, we applied the method of multidimensional scaling (Fig.1) to the matrix of genetic distances (Kruskal 1964). The individuals of each extant elephant species form a relatively dense group, whereas mammoths are divided into two groups (M1-M2-M3-M6 and M4-M5). It should be noted that relative positions of mammoths and elephants remain approximately the same in the cases where different numbers of dimensions are used (we tested the variants of two to six dimensions; the stress values were 0.0547, 0.0156, 0.0081, 0.0039, and 0.0024, respectively). The optimum number of dimensions is three that agrees with the presence of four different groups. The mean distance between the members of different mammoth

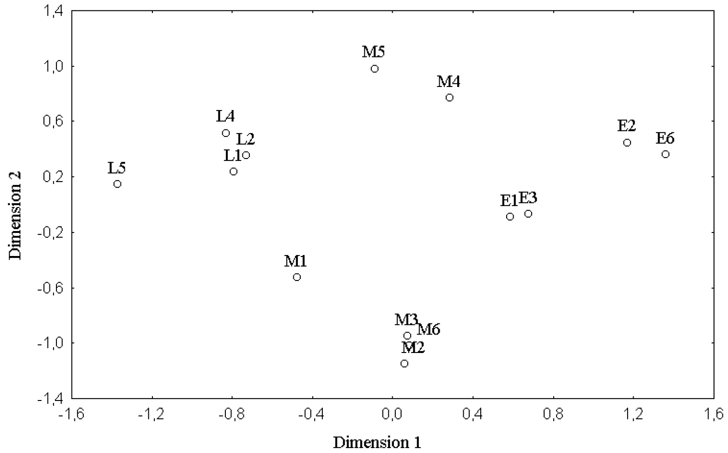

Fig.1 - The positions of mammoths and African and Asian elephants relative to the first two co-ordinate axes of multidimensional scaling of sequence distances based on a 218 base pairs of the cytochrome *b* gene. For designations of individuals, see the table.

groups is 0.042, i.e., approximately the same as between different elephant genera. This was the reason for the high mean distance within mammoths. At the same time, variation in either mammoth group is comparable to those in extant elephants, namely, the distance M4-M5 is 0.019 and the mean distance within M1-M2-M3-M6 is 0.014.

High differences between the mammoth groups could be explained by an extremely high diversity of *M. primigenius* or by belonging to different geographical or (and) temporal forms. The first possibility appears less probable because it implies that mammoths were substantially more diverse than living elephants. In addition, mammoths are divided into two genetic groups and intermediate individuals are absent.

Extremely high genetic differentiation within *M. primigenius* was also revealed in the study of the 16S rRNA gene fragment (Hoss *et al.* 1994). Four mammoths were examined and divided into two groups, the differences between which were comparable to or higher than the differences between Asian and African elephants.

Thus, the results of examination of the cytochrome *b* and 16S rRNA gene fragments allow us to assume that *M. primigenius* is probably represented by at least two forms (apparent twin species) isolated from each other almost simultaneously with the radiation of lineages of Asian and African elephants and mammoths. Since at the moment of divergence, common ancestor of *Loxodonta, Elephas* and *Mammuthus* was more similar in plesiomorphic characters to the African elephant than to the Asian elephant and mammoth (Rautian & Dubrovo 2001); common ancestor of two mammoth branches should resemble the African elephant (lacking the synapomorphies characteristic of the Asian elephant and mammoths) to a greater extent than the Asian elephant. Consequently, the synapomorphies of the Asian elephant and each mammoth branch arose independently in each lineage and were absent in common ancestor (the latter possessed only the potentiality for developing these characters). Additional substantiation of this statements necessitate a thorough morphological examination of common and distinctive features within and between elephantine groups. An evolutionary scheme showing the time of divergence and the extent of morphological advantage in the elephantines considered is shown in figure 2.

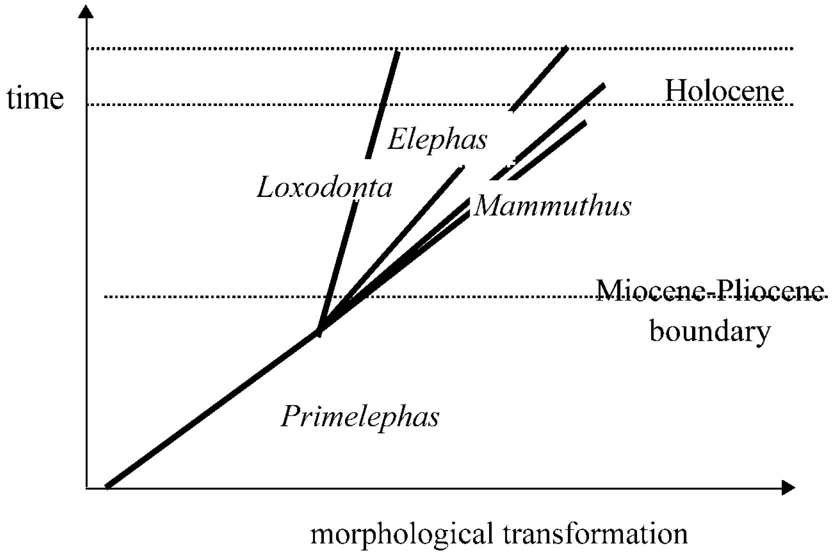

Fig.2 - Scheme of phylogenetic relationships among genetically studied elephantines. Relatively primitive morphological characters of *Loxodonta* are shown by its closer position to the common ancestor (relative to X-axis); similarity between *Elephas* and *Mammuthus* (represented by two lineages) in advanced morphological features are shown by their close position to each other and strong deviation from the ancestor. At the same time, the four forms radiated simultaneously, most probably at the boundary between the Miocene and Pliocene.

ACKNOWLEDGEMENTS

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REFERENCES

Dubrovo, I.A. & Rautian, G.S. 1999. Comparative Analysis of Genetic Diversity in Mammoth. 2*nd Int. Mammoth Conf., Amsterdam:* 15-17.

Hagelberg, E., Thomas, M.G., Cook, Ch.E. *et al.* 1994. DNA from ancient mammoth bones. *Nature* 370: 333-334.

Hoss, M., Pääbo, M. & Vereshchagin, N.K. 1994. Mammoth DNA sequences. *Nature* 370: 333.

Irwin, D.M., Kocher, T.D. & Wilson, A.C. 1991. Evolution of the cytochrome b gene of mammals. *J. Mol. Evol.* 30: 128-144.

Kimura, M. 1980. A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *J. Mol. Evol.* 16: 111-120.

Kimura, M. 1983. *The neutral theory of molecular evolution.* Cambridge: Cambridge University Press.

Kruskal, J.B. 1964. Non-metric Multidimensional Scaling: A Numerical Method. *Psychometrika* 29, 2: 115-129.

Lowenstein, J.M. 1985. Radioimmune assay of mammoth tissue. *Acta Zool. Fenn.* 170: 233-235.

Noro, M., Masuda, R., Dubrovo, I.A., Yoshida, M.C. & Kato, M. 1998. Molecular phylogenetic inference of the woolly mammoth *Mammuthus primigenius,* based on complete sequence of mitochondrial cytochrome *b* and 12S ribosomal RNA genes. *J. Mol. Evol.* 46: 314-326.

Ozawa, T., Hayashi, S. & Mikhelson, V.M. 1997. Phylogenetic position of mammoth and Steller's cow within Tethitheria demonstrated by Mitochondrial DNA sequences. *J. Mol. Evol.* 44: 406-413.

Rautian G.S. & Dubrovo I.A. 2001. The results of DNA examination in mammoth. In *Mammoth and its environment: 200 years of studying*. 112-123. Moscow: Geos.

Valente, A. 1983. Hair structure of the woolly mammoth *Mammuthus primigenius* and the modern elephants, *Elephas maximus* and *Loxodonta africana*. *J. Zool. (London)* 199: 271-274.

Yang, H., Golenberg, E.M., & Shoshani, J. 1996. Phylogenetic resolution within the Elephantidae using fossil DNA sequence from the American mastodon (*Mammut americanus*) as an outgroup. *Proc. Nat. Acad Sci. USA* 93: 1190-1194.

Observations on the diagenesis of dwarf elephant skeletal remains from the island of Tilos (Dodekanese, Greece)

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SUMMARY: The object of this analysis is the study of the diagenetic alterations that appear in bones from the Charkadio Cave on the island of Tilos (Dodekanese, Greece) that have been provisionally attributed to *Palaeoloxodon antiquus falconeri* Busk. The bone samples were studied through optical and scanning electron microscopy, X-ray microanalysis and X-ray diffraction, while the Ca/P ratio and Crystallinity Index (C.I.) were estimated.

1. INTRODUCTION

Bone is a heterogeneous, complicated dynamic system which consists of a dense framework of organised fibrils of collagen and a poorly crystallised hydroxylapatite ($Ca_{10}(PO_4)_6(OH)_2$) which always contains a certain amount of carbonate and thus is called carbonate hydroxylapatite (Posner 1985; Person *et al.* 1995). This biological apatite is characterised by a greater ion exchange than that of the mineral apatite, due to its smaller crystals. This leads to a significantly different chemical composition and the presence of many elements (Weiner & Price 1986). Bones crystallinity seems to increase with age, during both the animal's life and its journey from the biosphere to the lithosphere (Bonar *et al.* 1983). The procedures that lead to the preservation of bone through time are known as diagenesis and have been the object of many studies during the last decades (Hill 1980; Clarke *et al.* 1993; Hedges *et al.* 1995a, b). Diagenesis can be recognized by a number of alterations that occur at different stages from the time of death and which depend greatly on the existing geochemical conditions (Marean 1991).

These alterations may concern changes of bone histology and its preservation, the amount of organic matter within, its size and shape as well as the presence of intrusions and void filling by mineral phases. These last two changes are often connected to microbial activity, which occur from the very first hours postmortem. Dissolution and recrystallization of the apatitic phase and numerous ionic exchanges with the environment are also possible alterations, which in turn may lead to a differentiation of the Ca/P ratios, the crystallinity of bone etc (Hackett 1981; Piepenbrink 1989; Grupe 1995; Person *et al.* 1995).

2. MATERIALS AND METHODS

The material used in this study belongs to dwarf elephants that were originally attributed to the subspecies *Palaeoloxodon antiquus falconeri* Busk by Symeonidis (1972). Theodorou (1983) discusses the problem of using the same taxon for Tilos and Malta elephants and accepts it temporarily. Material coming from the last excavations will allow us the detailed description of the elephants and possibly their correct attribution to another taxon. These dwarf elephants dominate the cave fauna and which make it the richest dwarf elephant site in the world. Only 20% of the sediment coming from the first of the two known chambers has given an estimate of more than 40 elephants. These elephants are also considered to be the last elephants in Europe, as their appearance in the cave ranges from 45 to 4-3.5 ka. The rest of the cave fauna consists of deer (140 ka old), chelonia, aves and some micromammals (Symeonidis 1972; Bachmayer *et al.* 1976; Theodorou 1983, 1988).

Six bone samples where chosen (Fig. 1) from which samples 1-4 are costae and samples 5-6 are metapodials. Samples 1, 2 and 3 were taken from the region close to the cave wall (E position; Symeonidis 1976) and were covered by hardened cave deposits. The depth from which they were derived is 1.6 m from zero point for the first two and 0.7-1.1 m for sample 3. Sample 4 was dug up from square Q9 and the depth of 2.9 m from zero point and appears to be darker on the outer side than the rest of the samples. Samples 5 and 6 come from the depths of 0.7-1.3 m and 1.4-1.8 m respectively.

Thin sections of the above samples were studied both by optical and scanning electron microscopy, so as to observe the state of preservation of the internal structure of the bone and the mode in which diagenesis has affected it. For the same purpose, pieces of compact bone of each sample were also observed using scanning electron microscopy, after being covered by gold. Chemical analysis of both the samples and their surrounding sediment were obtained by X-ray microanalysis (EDS), while X-ray diffraction provided us with their mineralogical composition. The crystallinity index for each bone was also determined by means of this technique according to the method proposed by Person *et al.* (1995).

3. Results and Conclusions

The observation of our material under the microscope leads us to believe that diagenesis has not affected bone structure significantly. All regions of compact bone are covered by healthy osteons, which appear with all their characteristic features (Figs. 2, 3). There are no signs of microbial activity, while there are few signs of stress, which have lead to some cracking and deformation (Fig. 4). Apart from the apatitic phase one may observe voids (haversian tunnels, lacunae et canaliculi, cracks etc.) filled mainly by calcite (Figs. 2, 5) while small quantities of the surrounding sediment seem to have entered the structure in some regions.

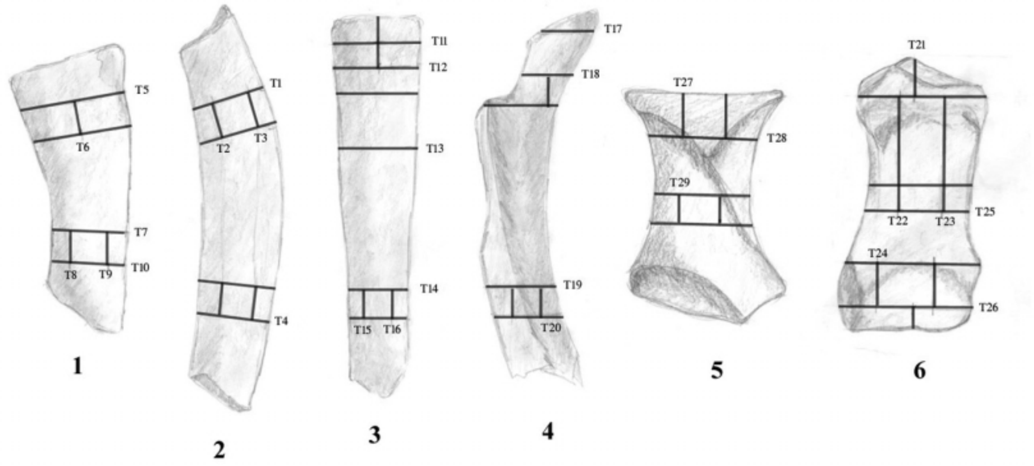

Fig.1 - The material selected for this study (33% of actual size). One may observe the position of the thin sections made on each bone.

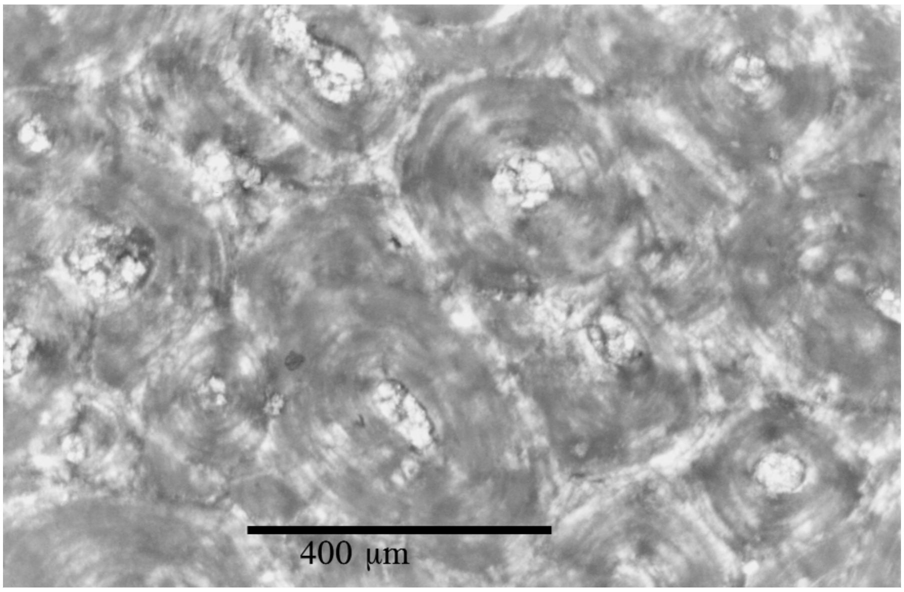

Fig.2 - Haversian systems under polarized light (section T4). Calcite filling all voids might also be observed.

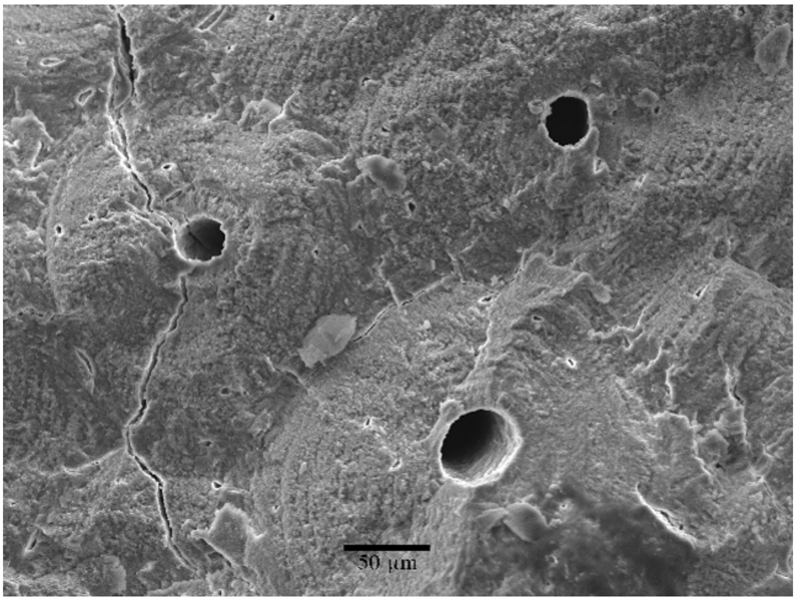

Fig.3 - The same features seen through the SEM (sample 4).

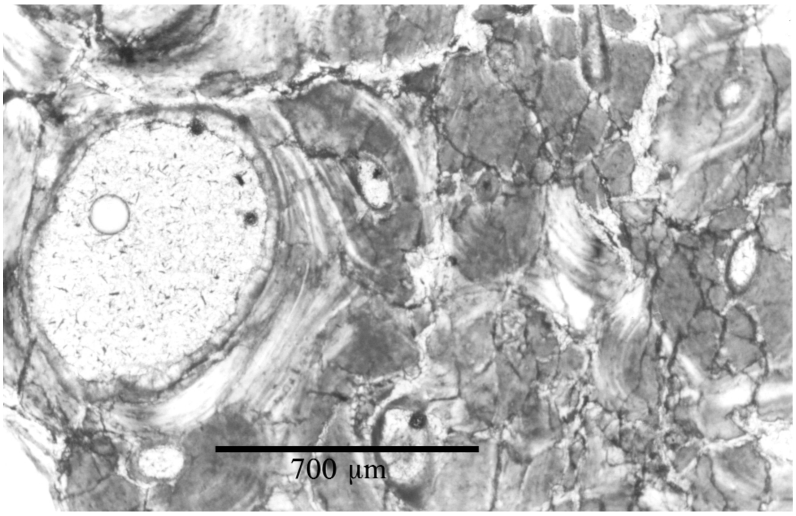

Fig.4 - Osteons of different sizes near the cancelous bone region under polarized light, with obvious signs of cracking (section T28).

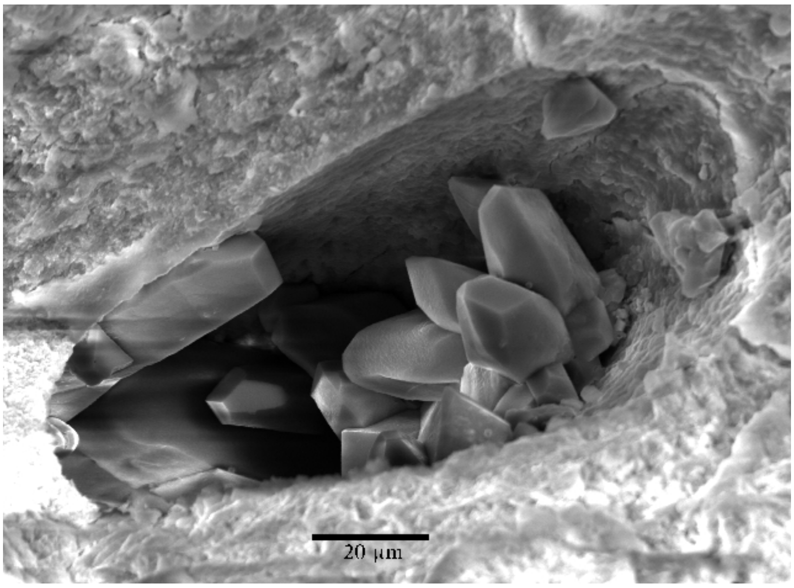

Fig.5 - Calcite crystals inside a haversial channel, seen through the SEM (sample 1).

The use of X-ray diffraction also proves the presence of other mineral phases apart from hydroxylapatite, which does not contain any fluorine. Calcite seems to dominate, since it appears in 5 out of 6 samples. Quartz is also present in smaller quantities (Tab. 1, Tuross *et al.* 1989). This conclusion derives from the value of the ratios given in Table 1. Their values are given by the division of the heighest peak of the mineral phase of interest by the highest peak of hydroxylapatite. The crystallinity index value is given by the sum of the heights of the peaks corresponding to reflections (211), (112), (300) divided by the height of the highest peak (211). It ranges between 0.2 and 0.44, and proves that the recrystallization of the biological apatite has already begun. These indexes are quite close to that of modern bone (0.0), a fact that generally characterizes material coming from cave deposits.

Tab.1 - Crystallinity indexes for each sample, as well as the ratios of calcite/hydroxylapatite and quartz/hydroxylapatite estimated by the XRD technique according to Tuross *et al*. (1989).

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Average
Crystallinity Index	0.3	0.2	0.26	0.44	0.22	0.27	0.28
Calcite/Hydroxylapatite	0.37	1.22	1.02		1.08	0.81	0.75
Quartz/Hydroxylapatite		0.15		0.16		0.31	0.1

Tab.2 - Average Chemical analysis (%) for each sample. All measurements of elements are in oxides except for Cl.

Oxides	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
SiO_2	0.81	1.87	0.25	1.26	0.93	0.46
Al_2O_3	0.23	0.22	0.12	0.26	0.22	0.23
MgO		0.44		0.47	0.32	
CaO	57.95	55.88	60.62	54.75	55.97	57.47
Na_2O	0.54	0.8	0.48	0.63	1.06	1
P_2O_5	38.02	39.26	36.97	41.49	38.86	38.33
SO_3	0.6	0.93	0.53	0.76	1.85	1.59
Cl	0.47			0.16	0.17	0.11
TOTAL	98.62	99.4	98.97	99.78	99.38	99.19
Ca/P	2.53	2.34	2.71	2.16	2.38	2.48

The surrounding sediments consist mainly of calcite, quartz, feldspars and clay minerals such as illite, montmorillonite etc. Their chemical composition shows apart from the above, quantities of phosphorous that range between 1.98% and 29.03%. This proves that bone has lost some of its P during its interaction with its surrounding media while this was obvious also by the Ca/P ratios.

Because of the mentioned intrusions and the interaction of the bone hydroxylapatite with the surrounding environment, the chemical composition of our samples shows an increase in elements such as Al, Si, Ca while others (Na, Mg, K) already exist in bone due to physiological needs ante mortem (Tab. 2). Ca/P ratios are quite close to those of modern bone (2.16) and are often increased due to the presence of calcite or the depletion or substitution of phosphorous (Stathopoulou 2000, and references within). Although the cave contains important layers of volcanic material, there seems to be no affect on the composition of the skeletal remains with Si appearing in relatively small quantities.

From the above, we conclude that the processes of diagenesis have obviously begun to affect the material being studied but are still at a primary stage. It is also obvious that some of these processes have affected the bone more than others. Further study will give us a clearer picture of the conditions that lead to the observed state of preservation and alterations.

4. ACKNOWLEDGEMENTS

We would like to thank Dr. N. Symeonidis who first discovered the Charkadio cave and gave us the opportunity to study it. Our thanks also, to the Ministry of the Aegean Sea for financing the research of the Charkadio cave (Projects 70/3/699 & 96ΣYN-106 E.L.K.E) and the General Secretary of Research and Technology. We would also like to acknowledge the Municipality of Tilos and the Mayor Mr. A. Aliferis for their support. Our appreciation to Mr. Mitsis of the Laboratory of Geochemistry and Economic Geology at Athens University for conducting the XRD analyses and to Mr. E. Mihailidis for his assistance during the observation and analysis of the specimens with the SEM-EDS. We also thank Dr. J. Bassiakos at at the N.C.S.R Demokritos for his important help in studying bone fossilization.

5. REFERENCES

Bachmayer, Von F., Symeonidis, N., Seeman, R., Zapfe, H. 1976. Die ausgrabungen in der Zwergelefantenhohle “Charkadio” auf der Insel Tilos (Dodekanes, Griechenland) in der Jahren 1974 und 1975. *Ann. Naturhistor. Mus. Wien* 80: 113-144.

Bonar, L.C., Roufosse, A.H., Sabine, W.K., Grynpas, M.D., Glimcher, M.J. 1983. X-Ray diffraction studies of the crystallinity of bone minerals in newly synthesised and density fractionated bone. *Calcified Tissue International* 35: 202-209.

Clarke, J.B., Barker, M.J. 1993. Diagenesis in *Iguanodon* Bones from the Wealden Group, Isle of Wight, Southern England. *Darmst. Beitrage zur Naturgeschichte* 2: 57-65.

Grupe, G. 1995. Preservation of collagen in bone from dry, sandy soil. *Journal of Archaeological Science* 22: 193-199.

Hackett, C.J. 1981. Microscopal focal destruction (tunnels) in exhumed human bones. *Medicine, Science and the Law* 21: 243-265.

Hedges, E. M., Millard, A.R. 1995a. Bones and groundwater: Towards the modeling of diagenetic processes. *Journal of Archaeological Science* 22: 155-164.

Hedges, E.M., Millard, A.R. 1995b. Measurements and relationships of diagenetic alteration of bone from three archaeological sites. *Journal of Archaeological Science* 22: 201-209.

Hill, A.P. 1980. Early post-mortem damage to the remains of some contemporary East African mammals. In A. K. Behrensmeyer & A P. Hill (eds.), *Fossils in the making - Vertebrate Taphonomy and Palaeoecology:* 131-152. The University of Chicago Press.

Marean, C.W. 1991. Measuring the post-depositional destruction of bone in archaeological assemblages. *Journal of Archaeological Science* 18: 677-694.

Person, A., Bocherens, H., Saliege, J.F., Paris, F., Zeitoun, V., Gerard, M. 1995. Early diagenetic evolution of bone phosphate: an X-Ray Diffractometry analysis. *Journal of Archaeological Science* 22: 211-221.

Piepenbrink, H. 1989. Examples of chemical changes during fossilization. *Applied Geochemistry* 4: 273-280.

Posner, A.S. 1985. The mineral of Bone. *Clinical Orthopaedics* 200: 87-99.

Stathopoulou, E. 2000. Study of the processes of Fossilization and the interaction with the environment of Neogene and Quaternary Vertebrate bones. *Unpub. MSc thesis. Athens University*. 207 p.

Symeonidis, N.K. 1972. Die entdeckung von Zwergelefanten inder Hohle “Charkadio” auf der insel Tilos (Dodekanes, Griechenland). *Annales Géologiques des Pays Hélleniques* 24: 445-461.

Theodorou, G. 1983. *The dwarf Elephants of the Charkadio Cave on the island of Tilos (Dodekanese, Greece)*. PhD Dissertation. 231 p. Athens.

Theodorou, G. 1988. *Environmental factors affecting the evolution of island endemics: The Tilos example from Greece.* Modern Geology 13: 183-188.

Tuross, N., Behrensmeyer, A.K., Eanes, E.D., Fisher, L.W., Hare, P.E. 1989. Molecular preservation and crystallographic alterations in a weathering sequence of wildebeest bones. *Applied Geochemistry* 4: 261-270.

Weiner, S., Price, P.A.P. 1986. Dissagregation of bone into crystals. *Calcified Tissue International* 39: 365-375.

Observations on the microstructure of fossil tusks from the Charkadio cave (Tilos, Dodekanese, Greece)

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SUMMARY: Two fossil tusks of the dwarf elephants from the Quaternary locality of Tilos from (45 ka BP to 4-3.5 ka BP) were studied in regard to the microstructure of the dentine part. Measurements were taken of the dentinal tubule density and of the Schreger angles. These were compared to known values for mammoths, mastodones, and the two extant elephant species. These measurements suggest a closer relation of the dwarf elephants from Tilos to the extant species than to mammoths. Also the dentinal tubule density of the two specimens features a wide range that requires further study, especially regarding the ontogenetic stage of the animal.

1. Scope, Material and Methodology

The scope of this study is to increase our knowledge of the internal structure of the dwarf elephant tusks from the Charkadio Cave on the island of Tilos. The skeletal parts of the species first appear in the sediments of the cave about 45 ka BP and become extinct almost 4-3.5 ka BP (Symeonides 1972, Bachmayer *et al.* 1976, 1984, Theodorou 1983, 1988). The material had originally been designated to *Palaeoloxodon antiquus falconeri* Busk (Symeonidis 1972). However, this name refers to the dwarf elephants from the island of Malta. As a result, since no migration route between the two islands can be proved, this name should not be used when referring to the elephant remnants from Tilos. Theodorou (1983) has accepted the temporal use of this name, until further material can be examined (Theodorou & Symeonidis 2001, this volume).

The samples were selected according to the degree of completeness and preservation of the tusk. Two tusks were selected, one from a juvenile individual (T.00/144), and one from an adult one (T.00/53). Both tusks are lacking tip and base and appear extremely fragmented and brittle. However the relative position of the fragments can still be indicated. The tusk sample T.00/144 has a length of 20.55 cm from proximal to distal end (arch), while the same measurement for the tusk sample T.00/53 is 47.00 cm. The maximum and minimum diameters at the middle of the tusk are 4.05 cm and 3.65 cm respectively, for the tusk sample T.00/144. The same diameters for the tusk sample T.00/53 measure at 9.50 cm and 7.50 cm respectively. The mean width of the cementum layer is 3 mm for T.00/144 and 4 mm for T.00/53.

The sample T.00/144 was studied by optical analysis of the Schreger angles (OASA). In the preparation of the sections two aspects had to be considered: the fragility of the tusk and the consequent examination under the SEM. In order to avoid embedding, the tusk was encased in plaster. Ten transverse sections were made, recording the distance of each section from the proximal end of the tusk. The surfaces created were sufficiently flat, so that no polishing would be required. Afterwards, the sections were scanned, with a resolution of 1000 dpi, and the images were processed with a photo-processing program. The Schreger angles were then measured at high magnification.

The dentinal tubule density can be measured on microphotographs of fractured surfaces (Forssell-Ahlberg *et al.* 1975), chosen parallel to the periphery of the tusk.

Thirty stub samples were taken from several points along the inner surface of the cementum-dentine junction (CDJ), of both tusks, in order to observe the circumferential surface of the tusk under the SEM. The sample surface was covered with a conductive gold layer to evacuate charges.

2. OBSERVATIONS

On sample T.00/144, we can easily distinguish the Schreger lines intersecting to form concave and convex angles. A total of 145 measurements of convex angles were taken at varying distances from the CDJ.

From the stubs examined under the SEM, the dentinal tubule density was calculated on a total of 26 distinct areas on the 15 stub samples of the tusk sample T.00/144 and 24 distinct areas on the 15 stub samples of the tusk sample T.00/53 (Tab. 1).

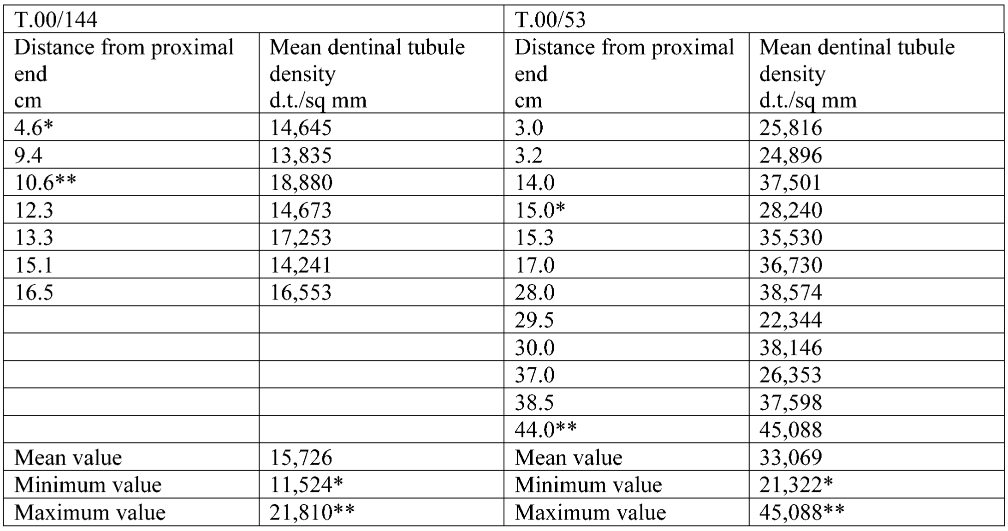
3. RESULTS

According to Hildebolt *et al.* (1986) "*tubule densities measured at specific distances from the pulp vary according to how much dentine has formed*". As a result, we would expect the dentinal tubule density in tusks to increase proximally. This is not the case in the tusk samples examined here, where the density does not seem to correlate with the distance from the proximal end. This may be explained if we also consider the degree of branching of the tubules towards the CDJ.

The mean dentinal tubule density of the tusk of the juvenile individual is almost half the mean density of the tusk of the adult animal, although the measurements in both cases were taken near the cementum-dentine junction. This could be indicative of a dependency on age, although it may not necessarily be so. Garberoglio & Brannstrom (1976) in their study of human dentinal tubules, state that "no great difference was observed between old and young teeth". Also in a preliminary research by J. Trapani (pers. comm.) the dentinal tubule densities in samples of mammoths (*Mammuthus primigenius*, *M. columbi*) ranged between 24,100-41,400 dentinal tubules per square millimetre (d.t./sq mm). While, in the same study, samples from *Mammut americanum* measured between 15,200-41,600 d.t./sq mm. Obviously, such a wide range could also exist in the tusks of the dwarf elephants of Tilos. In any case, we should examine this feature in relation to the ontogeny of the animal.

According to Espinoza & Mann (1992) the

Tab.1



T.00/144		T.00/53	
Distance from proximal end cm	Mean dentinal tubule density d.t./sq mm	Distance from proximal end cm	Mean dentinal tubule density d.t./sq mm
4.6*	14,645	3.0	25,816
9.4	13,835	3.2	24,896
10.6**	18,880	14.0	37,501
12.3	14,673	15.0*	28,240
13.3	17,253	15.3	35,530
15.1	14,241	17.0	36,730
16.5	16,553	28.0	38,574
		29.5	22,344
		30.0	38,146
		37.0	26,353
		38.5	37,598
		44.0**	45,088
Mean value	15,726	Mean value	33,069
Minimum value	11,524*	Minimum value	21,322*
Maximum value	21,810**	Maximum value	45,088**

*, ** The asterisks connect the minimum and maximum values to the corresponding distances from the proximal end.

mean outer Schreger angles for *Mammuthus primigenius* is 73.21°, while the same mean for *Loxodonta africana* and *Elephas maximus* (undifferentiated) is 124.15°, and these values overlap between 90° and 115°. Also Fisher *et al.* (1998) measuring maximal angles on tusk specimens give a mean value of 87.1° for mammoths (*M. primigenius, M. columbi* and *Mammuthus* sp.) and a mean of 124.7° for mastodons (*Mammut americanum*). In our case, the sample analysed measure outer angles (distance from CDJ < 2 mm) ranging from 119° to 158.5°, with a mean of 142°. In their study, Fisher *et al.* (1998) also state that the maximal angle increases proximally. By plotting the angle measurements on our sample against the distance from the proximal end of the tusk, we observe that the same occurs here (Fig. 1).

Poulakakis (unpubl. MSc Thesis) compared DNA samples of the “*Palaeoloxodon antiquus falconeri*” of Tilos to those from *Mammuthus primigenius* and the extant Proboscidean species. He places the dwarf elephants of Tilos in closer affinity to the *Elephas maximus*. Indeed the measurement of Schreger angles would tend to place the dwarf elephants of Tilos closer to the extant species than mammoths, although the dentinal tubule densities do not provide any differentiation at this point. In order to reach a more definite conclusion, we should compare the mean values of the angle, at any given position, using more specimens from adult individuals.

4. DISCUSSION

Although the dentinal tubule density plotted against the distance from the proximal end does not provide a distinctive pattern, this should be examined further in more tusk samples. The fact that the Schreger pattern, which is directly related to the distribution of the dentinal tubules (Miles & Boyde 1961), is “taxon – specific” (Trapani 1998) must be considered. The branching of the dentinal tubules near the CDJ may complement for greater distance from the pulp to maintain the density of the tubules relatively stable. Even so, plotting tubule density against distance from the pulp at any given position could provide a differentiating method.

Evidently, the many issues that arise from this study require further examination. The use of more tusk samples from adult individuals

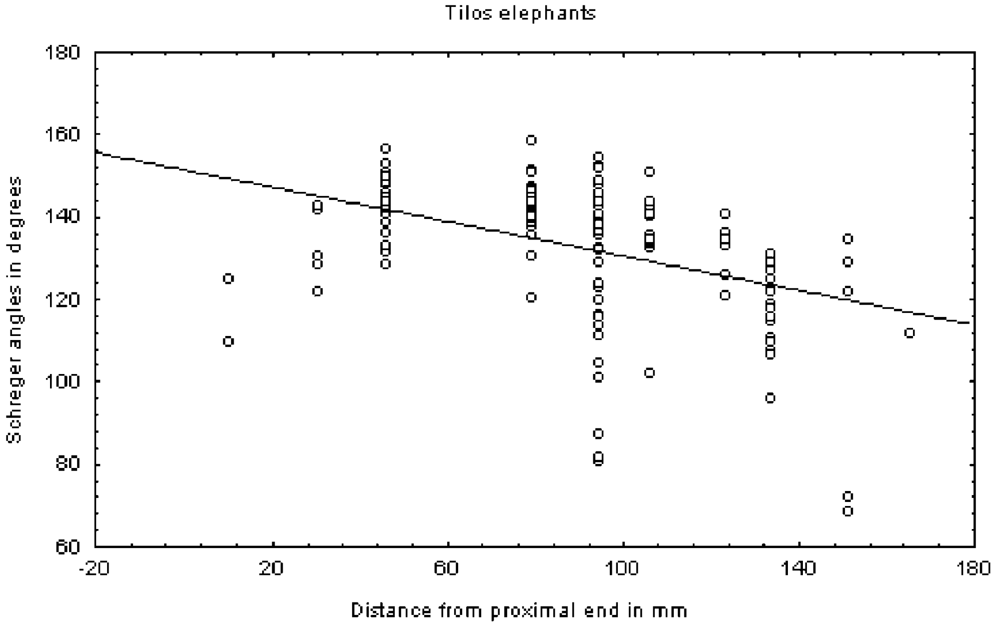


Fig.1 - The Schreger angle increases proximally.

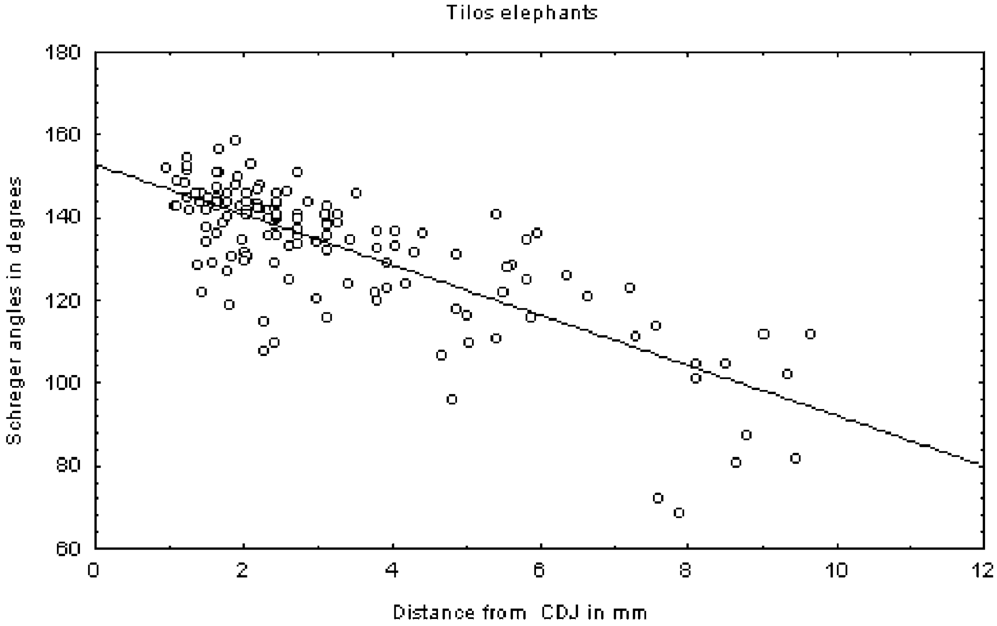


Fig.2 - The Schreger angle increases with greater distance from the pulp cavity.

appears necessary, in order to reach more definite conclusions. Of course, the rarity of the fossil tusk samples and the destructiveness of the method have to be considered as well.

5. Acknowledgements

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6. References

Bachmayer, Fr., Symeonidis N., Seeman R., Zapfe H. 1976. Die Ausgrabungen in der Zwergelefantenhohle “Charkadio” auf der Islel Tilos (Dodekanes, Griechenland) in der Jahren 1974 und 1975. *Ann. Naturhistor. Mus. Wien* 80: 113-144.

Bachmayer, Fr., Symeonidis N., Zapfe H. 1984. Die Ausgrabungen in der Zwergelefantenhöhle der Insel Tilos (Dodekannes, Griechenland) im Jahr 1983, *Sitzungsberichten der Österr. Akademie der Wissenschaften Mathem.-naturw. Kl.*, Abt.I. 193: 6-10.

Bradford, E.W. 1967. Microanatomy and Histochemistry of Dentine. In A.E.W. Miles (ed.), *Structural and chemical organization of teeth*, Vol.2: 3-33. London: Academic Press.

Boyde, A. & Lester K.S. 1967. An electron microscope study of fractured dentinal surfaces. *Calcified Tissue Research* 1: 122-136.

Espinoza, E.O. & Mann, M.J. 1992. *Identification guide for ivory and ivory substitutes*. WWF Publications.

Espinoza, E.O. & Mann, M.J. 1993. The history and significance of the Schreger Pattern in Proboscidean ivory characterization. *Journal of the American Institute for Conservation* 32: 241-248.

Fischer, D.C., Trapani, J., Shoshani, J., Woodford, M.S. 1998. Schreger angles in mammoth and mastodon tusk dentin. *Current research in the Pleistocene* 15: 105-107.

Forssell-Ahlberg, K., Brannstrom, M., Edwall L. 1975. The diameter and number of dentinal tubules in rat, cat, dog and monkey. *Acta Odont. Scand.* 33: 243-250.

Garberoglio, R. & Brannstrom, M. 1976. Scanning electron microscopic investigation of human dentinal tubules. *Archives of Oral Biology* 21: 355-362.

Hildebolt, C.F., Bate, G., McKee, J.K., Conroy G.C. 1986. The microstructure of dentine in taxonomic and phylogenetic studies. *American Journal of Physical Anthropology* 70: 39-46.

Miles, A.E.W. & Boyde, A. 1961. Observations on the structure of elephant ivory. *Journal of Anatomy* 95: 450.

Symeonidis, N.K. 1972. Die entdeckung von Zwergelefanten inder Hohle “Charkadio” auf der Insel Tilos (Dodekanes, Griechenland), *Ann. Géol. des Pays Hellén.* 24: 445-461.

Theodorou, G. 1983. *The dwarf elephants of the Charkadio cave on the island of Tilos (Dodekanese, Greece).* PhD Thesis. University of Athens.

Theodorou, G. 1988. Environmental factors affecting the evolution of island endemics: The Tilos example from Greece. *Modern Geology* 13, 183-188.

Trapani, J. & Fisher D.C. 1998. Schreger angle gradients in Proboscidean tusk dentin. *Journal of Vertebrate Paleontology* 18 (3): 2A.

Elephant landscapes: human foragers in the world of mammoths, mastodonts, and elephants

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SUMMARY: Human groups able to subsist by opportunistic exploitation of proboscideans would be afforded abundant environmental clues to prey health and density, along with superior nutrients and other advantages such as information-rich trail networks.

1. INTRODUCTION: ELEPHANTS AND PEOPLE

Elephants are keystone species (Owen-Smith 1999, 1989, 1987) whose behavior alters ecosystems. The behavior of extinct mammoths and mastodonts not only partly re-engineered Pleistocene ecosystems, but it also contributed the information and enhancements which made rapid human exploration, dispersal, and colonizations so successful during the late Pleistocene.

2. ELEPHANT LANDSCAPES

2.1 Trackways and dung

Foragers who pay attention to the signs left by proboscideans can gather significant information that will aid in subsistence activity. For example, by examining proboscidean spoor, human foragers can gain crucial knowledge about individual animal sizes, ages, and locomotion speed, without laying eyes on the prey animals themselves. Track-size allows an estimate of elephant shoulder heights (height = ca. twice the front-foot circumference), and shoulder height correlates with animal age. Visual traces of feeding are often abundant, such as broken and debarked trees, excavated roots, and pulled-up grass.

Elephants are bulk feeders and inefficient processors, and only around 50% of intake is digested (Benedict 1936). Adult elephants ingest around 150 kg (330 lbs) of forage every day, feeding at all times of the day, and hence dung is abundant (over 100 kg a day) and well scattered over their daily range (Laws *et al.* 1975; Sikes 1971). Elephants travel at different speeds, ranging from a brisk walk (which approaches the speed of a human run) to a leisurely amble (which is similar to a slow human jog). Dung passed at different locomotion speeds is broken differently upon impact with the ground, providing a clue to the speed of moving animals. Human foragers can examine elephant dung – as do modern biologists who study elephant populations – to determine individual animal sizes, age and sex, locomotion speed, direction of travel, and feeding patterns (Barnes & Jensen 1987). Dung provides important clues about proboscidean health, reflected in the dung's moisture content, unchewed and recognizable plant parts, fiber lengths which reflect the condition of the teeth (Fig. 1), fruits and seeds fed upon over the last 2 days but which may be carried long distances in the gut (Dudley 1999; Janzen & Martin 1982), and the inorganic component in digesta, such as sand, unchewed wood, or other unusual objects, ingested when elephants are very hungry (Fig. 2).

Fig.1 - Unchewed leaves and long bark fibers in dung of *Loxodonta africana*, poorly chewed and undigested when passed.

Fig.2 - The skeleton of an Amethyst or Plum-colored Starling (*Cinnyricinclus leocogaster*) (just above the left end of the 15-cm ruler) in the stomach contents of a very old female African elephant. The bird was swallowed unchewed by a starving elephant.

Dung provides organic matter that replenishes soil nutrients, and feeds many taxa of arthropods such as dung beetles. However, elephants trample soils around preferred water and feeding patches, sometimes with damaging effects, partly offsetting the advantages of high dung input. Elephants also dig for tree-roots, or kick at grass-tufts to pull them up for feeding, thus sometimes seriously disturbing ground cover.

2.2 Trail networks

Modern proboscideans make complex mental maps of water points, mineral sources, forage patches, fruit trees, travel routes, and socializing sites. Their travel routes between these important places can be easily followed by human foragers and other animal taxa. Proboscidean trails are wide, flat, and identifiably distinct from trails created or used by other animal taxa (Fig. 3). Proboscideans frequently move long distances, exploring for new forage, new mates, or new ranges. Proboscideans also habitually re-use old trails seasonally or more often, thus establishing clear networks of widely separated places connected by paths. Such networks of fixed and dependable trails would provide a means to encourage exploratory mobility by human pioneers into new ranges.

Fig.3 - An African elephant trail. Aerial photographs taken over the past 50 years in Zimbabwe show that trails are located in exactly the same locations year after year.

Fig.4 - Deep pit excavated by African elephants feeding on the mineral sediments.

2.3 Modified terrains

Proboscideans physically create and modify landscape features. For example, elephants create and enlarge mud wallows, excavate mineral pits (Fig. 4), enlarge water points through wallowing and removal of sediments, and excavate streambed or seepage wells. Hence, besides acting to attract other animals and different plant associations to the enlarged water or mineral sources, proboscidean modifications to terrains provide clues about general landscape drainage and hydrology even in nearly featureless physiography.

Proboscidean feeding on certain plants such as trees and bushes affects overall range productivity. For example, pruned woody vegetation may grow back vigorously. African mopane (*Colophospermum mopane*) coppices freely when browsed by elephants. Trees with similar habits in the Pleistocene would have responded to mammoth or mastodont browsing with thick new growth. In African woodlands, mopane re-growth is more palatable for herbivores than older growth because it lacks secondary compounds (antiherbivory defenses). Patches where heavily browsed plants coppice in response to proboscidean browsing can be counted on to attract other herbivores besides elephants, reducing human foraging search-times and also providing abundant growth of withes and branches that may be useful as staffs, sticks, or spears. Proboscidean browsing also may be great enough to create and maintain grassy open glades in wooded habitats where nonmigratory grazers could congregate (Owen-Smith 1999). Proboscideans digging up tree-roots and stripping tree-bark in wooded habitats provide human foragers with additional clues to the animals' health and nutrition.

2.4 Refugia

Proboscideans in habitat refugia may provide human foragers with scavengeable carcasses (see Haynes 1991), as well as a tethered population of vulnerable live animals crowded around remnant water sources (Fig. 5), surviving food patches, or micronutrient sources such as mineral springs and cobalt/selenium/iodine sources (Milewski & Diamond 2000; Milewski 2000).

Fig.5 - African elephants at a natural water source during a drought year in Zimbabwe.

In Zimbabwe, elephants aggregate around the last remaining natural water sources during drought years. There they dig deep wells in surficially dry stream channels, thereby providing water – for themselves and other animals – in ranges where no other water can be found. Elephant die-offs take place in such refugia patches, where water is scarce, but the main cause of death usually is starvation rather than severe dehydration, as elephant feeding-pressure mounts to unsustainable levels within walking distance of the last water sources. Recent research indicates that die-off age-profiles do differ measurably when either food or water scarcity causes most deaths.

There may have been important behavioral differences between the recent and the extinct taxa. Modern elephants ingest huge amounts of water, much of which is later urinated. Conceivably, some of the water ingested may provide more than moisture alone, supplying critical micronutrients and minerals, accounting for the apparent excessive water intake (A. V. Milewski, pers. comm.). Proboscideans such as extinct mammoths and mastodonts in habitats that provided ample minerals and micronutrients may not have needed to drink as often or as much as do modern elephants, thus avoiding chronic tethering to water. This sort of possible behavioral difference can be further explored by examining different water intake rates of elephants in different habitats, different distributions of fossil mammoth and mastodont bones correlated with local mineralogy and hydrology, and other such topics.

3. “ELEPHANT” LANSCAPE IN PREHISTORY

The effects that proboscideans have on landscapes make those landscapes especially appealing to mobile hunter-gatherers. An immense trail network can be followed on exploratory treks, reducing risks of getting lost or of not finding prey on the trails linking patches of high faunal biomass such as dependable water sources or fruit-tree stands.

In North America 11,500 ^{14}C yr BP, fluted-point-making people opportunistically targeted megamammals in habitat refugia during the last millennia of the Pleistocene, and, by exploiting mammoths and mastodonts, expanded their range widely in a very short span of time. The spread and success of fluted-point cultures were primarily due to human exploration of landscapes altered by proboscideans (Haynes 1999).

Similar kinds of opportunistic dispersals of late Pleistocene human groups probably occurred throughout the rest of the northern hemisphere, contributing to rapid human re-colonization and megamammal extinctions after the Last Glacial Maximum. Mammoth trails connected water points and led exploring humans to high-biomass patches, making human dispersals much less risky and much more rapid.

4. REFERENCES

Barnes, R.F.W. & Jensen, K.L. 1987. How to count elephants in forests. *African Elephant and Rhino Specialist Group Technical Bulletin*.

Benedict, F.G. 1936. *The physiology of the elephant*. Washington, D.C.: Carnegie Institution.

Dudley, J.P. 1999. Seed dispersal of *Acacia erioloba* by African bush elephants in Hwange National Park, Zimbabwe. *African J. Ecol.* 37(4): 375-385.

Haynes, G. 1991. *Mammoths, mastodonts, and elephants: biology, behavior, and the fossil record.* Cambridge: Cambridge University Press.

Haynes, G. 1999. The role of mammoths in rapid Clovis dispersal. In G. Haynes, J. Klimowicz & J. W. F. Reumer (eds.) Mammoths and the Mammoth Fauna: Studies of an Extinct Ecosystem. *Deinsea* 6: 9-38.

Janzen, D.H., & Martin, P.S. 1982. Neotropical anachronisms: The fruits the gomphotheres ate. *Science* 215: 19-27.

Laws, R.M., Parker, I.S.C., & Johnstone, R. C.B. 1975. *Elephants and their habitats:*

the ecology of elephants in North Bunyoro, Uganda. Oxford: Clarendon Press.

Milewski, A.V. 2000. Iodine as a possible controlling nutrient for elephant populations. *Pachyderm* 28: 78-90.

Milewski, A.V., & Diamond, R.E. 2000. Why are very large herbivores absent from Australia? A new theory of micronutrients. *Journal of Biogeography* 27: 957-978.

Owen-Smith, R.N. 1987. Pleistocene extinctions: The pivotal role of megaherbivores. *Paleobiology* 13: 351-362.

Owen-Smith, R.N. 1988. *Megaherbivores: The influence of very large body size on ecology*. Cambridge: Cambridge University Press.

Owen-Smith, R.N. 1999. The interaction of humans, megaherbivores, and habitats in the late Pleistocene extinction event. In R.D.E. MacPhee (ed.), *Extinctions in Near Time: Causes, Contexts, and Consequences:* 57-69. New York: Kluwer Academic/Plenum Publishers.

Sikes, S.K. 1971. *The natural history of the African elephant*. New York: American Elsevier.

Enforcement methods and tools for the elephant ivory

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SUMMARY: After the explorations and the conquest of the African and Asian continents, the trade of ivory got at unsustainable levels, leading the number of African and Indian elephants to a considerable decrease. Since 1973 the Indian elephant is included in Appendix I of the Convention on International Trade in Endangered Species of Wild fauna and flora (CITES), while the African elephant was included in 1989. In 1997, in Harare, during the X° International Conference of CITES, the African elephant has been down listed from Appendix I to Appendix II for some African countries: Botswana, Zimbabwe and Namibia. Several government and environmental organisations and different monitoring projects check the demographic situation of elephants. Nevertheless, illegal trafficking of ivory keeps on increasing as the customer demand increases. The main international routes of the illegal traffic of ivory involve above all countries like China and Japan, often transiting through European countries. From the recent years data analysis of the specimens seized at the main Italian ports and airports by personnel of Corpo forestale dello Stato (tusks, raw and worked, statues, necklaces), it resulted a trend consisting in illegal introduction of ivory following a non-EU Community passenger, coming from countries as Cameroun, China, Congo, Ivory Coast, Nigeria, South Africa, Thailandia. In these last years also the trade of mammoth tusks has become flourishing, because it is not illegal; therefore scientific methods (study of Schreger lines and angles, etc.) have been applied to distinguish ivory of extinct species from ivory of living species and they became very important and useful tools to prevent the renewal of illegal ivory trade.

1. INTRODUCTION

After the explorations and the conquest of African and Asian continents, the trade of ivory got at unsustainable levels, leading the number of African and Indian elephants to a considerable decrease.

Since 1973, including the Indian elephant in Appendix I and subsequently, in 1989, the African elephant too, the Convention on International Trade in Endangered Species of Wild fauna and flora (CITES) has looked like saving the elephants, that were in risk of extinction for illegal-hunting.

In 1997, in Harare, during the X° International Conference of CITES, the African elephant has been down listed from Appendix I to Appendix II for some African countries: Botswana, Zimbabwe and Namibia.

The demographic situation about elephants has been checked, during recent years, by several government and environmental organisations and by different monitoring projects. For example, in February 1999, the project MIKE (Monitoring Illegal Killing of Elephants) was approved to clash the illegal trade of ivory. At the beginning of 2000 the MIKE and the ETIS (Elephant Trade Information System) have become operative, helping the CITES and preventing a renewal of ivory traffic.

2. DISCUSSION

Nevertheless, illegal trade of ivory keeps on. As far as the ivory seizures made in Italy are concerned, from the analysis of data related to the ivory specimens introduced into the Judiciary Storage of the Seized and Confiscated specimens of Corpo Forestale dello Stato (Figs. 1, 2), it resulted that the irregulari-

Fig.1 - Ivory seized by Corpo Forestale dello Stato.

Fig.2 - Cawed ivory seized by Corpo Forestale dello Stato.

ties detected at the time of introduction in Italy reduced, going from the 392 infractions of the period 1993-1996 to 82 infractions of the period 1997-2000.

On one side, that trend is justified by the increased knowledge of the CITES and the national law disposals, even if it do not means that illegal traffic of ivory is disappearing.

In fact, in this analysis it is important to consider that in the international frame of the illegal trade in wildlife specimens, a lot of other fashions appeared besides ivory, and above all, as the control increased, the illegal traffic routes, changed, also for ivory, taking advantage of the progressive abatement of customs barriers among the European Community States. Therefore the points of introduction increased besides the national border and the investigative action on the territory shall be more and more ultranational.

From 1999 to the first months of 2001, at the main Italian ports and airports, personnel of Corpo forestale dello Stato seized about 300 specimens of elephant ivory, of the *Loxodonta africana* species, generally tusks, raw and worked, stutues, necklaces (Figs. 3, 4), for an amount of 250 kilos.

From the data analysis, it resulted a trend consisting in illegal introduction of ivory following a non -EU Community passenger, coming from

Fig.3 - Tusks and ivory figurines seized by Corpo Forestale dello Stato.

Fig.4 - Ivory necklaces and tusks seized by Corpo Forestale dello Stato.

countries such as Cameroun, China, Congo, Ivory Coast, Nigeria, South Africa, Thailandia.

With regard to the other European Union Member States, like France and United Kingdom, Italy has not a particular active market in the field of ivory products, and in fact the introduction and sale of ivory is concentrated in the above mentioned two countries.

3. CONCLUSION

The illegal trafficking increases as the customer demand increases. In fact, the main international routes of the illegal traffic of ivory, showed up by the large quantities seized, involve above all countries like China and Japan, often transiting through European countries, as it is herewith indicated: Nigeria – Taiwan (April 1998, 1,5 ton), Nigeria – China – via Moscow (April 1999, 0,5 ton), Cameroun – China – via Paris (October 1998, 600 kg), Cameroun – China – via Kenya (August 1999, 700 kg), Angola – Portugal (February 2000, 150 kg), South Africa – China (January 1999, 2 ton), South Africa – China – via Lisbona (October 1999, 1,5 ton), Kenya – Dubai (September 1999, 2 ton), Rwanda – Japon – via Paris (December 1999, 420 kg).

In these last years also the trade of mammoth tusks has become flourishing, because it is not illegal. These tusks are imported especially from East Europe (Siberia and Russia) and the North of United States (Alaska). Therefore, the poachers often cheat several States trading illegal ivory disguised as legal ivory; selling, in this way, an enormous quantity of elephant tusks.

In Italy, the illegal trade of ivory is still flourishing, and then it is seem considerably useful to inquire into scientific methods to distinguish ivory of extinct species from ivory of living species.

The study of Schreger lines and angles has been very important to single out two different patterns for allow CITES (and other customs examination) to prevent the renewal of illegal trade ivory. Also identification techniques to distinguish ivory from substitutive substances of ivory were studied and applied.

4. REFERENCES

Agenbroad, L.D. 1984. New World Mammoth Distribution. In Martin, P.S. & Klein, R.G. *Quaternary Extinctions*. The University of Arizona Press.

Banfi, E. 1998. Analisi dei movimenti migratori degli elefanti (*Loxodonta Africana Africana*) nell’area del Tarangire (Tanzania). Tesi di Laurea. Università degli Studi dell’Insubria.

Deraniyagala, P.E.P. 1955. *Some Extinct Elephants, Their Relatives And The Two Living Species*. Colombo: Ceylon National Museums Publication.

Douglas-Hamilton, I. 1987. African Elephants: Population trends and their causes. *Oxyx*, 21 (1): 11-24.

Douglas-Hamilton, I.E., Douglas-Hamilton, O. 1992. *Una Vita per gli Elefanti*. Gruppo Editoriale Armenia, Pan, Geo S.P.A.

Espinoza, E.O. & Mann, M.J. 1992. *Identification Guide for Ivory and Ivory Substitutes.* World Wildlife Fund Publication.

Espinoza, E.O. & Mann, M.J. 1993. The history and significance of the Schreger Pattern in Proboscidean ivory characterization. *Jaic* 32: 241-248.

Espinoza, E.O., Mann, M.J., Lemay, J.P., Oakes, K.A. 1990. A method for differentiating moderm from ancient Proboscidean ivory in worked objects. *Current Research in the Pleistocene* 7: 81-83.

Fisher, D.C., Shoshani, J., Woodford, M.S. 1998. Schreger angles in Mammoth and Mastodon tusk dentin. *Paleoenviroments: Vertebrata. Cpr.* 15: 105-106.

Mereu, U. 1992. *La Convenzione di Washington sul commercio internazionale delle specie di fauna e floro minacciate di estinzione*. Collana Verde del Ministero dell’Agricoltura e Foreste.

Mereu, U. 1995. *Commercio e tutela di animali e piante*. Roma: Cites.

Moss, C. 1988. *Elephant Memories*. William Morrow & Company.

Palombo, M.R. & Villa P. 2000. Schreger Lines as support in the Elephantinae classification. *Congrés “Les Ongulés Holarctiques du Pliocene et du Pleistocéne”, 19-22 Septembre 2000, Avignon. Résumés.*

Shoshani, J. 1992. *Elephants*. Weldon Owen.

Shoshani, J. & Eisenberg, J.F. 1982. *Elephas Maximus.* Manual Species 182: 1-8.

Thornton, A.E, & Currey, D. 1991. *To Save An Elephant*. Transword Publishers Ltd.

The Canadian perspective on the control of elephant products under the Convention of International Trade in Endangered Species of Fauna and Flora (CITES)

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CONTEXT

More liberal Trade

Since the creation of CITES international trade has change significantly. Time required to move shipments has been reduced and importers and exporters do not accept long delays to allow inspection at port of entry. The opening of large free trade agreements has reduce the need for customs presence.

Increase of volume of trade

Volume and types of products being transported from one country to the other has increased to reach a level impossible to physically inspect. In Canada, shipments can come via 276 ports of entry including airports, marine ports and road crossings.

TYPE OF CONTROL

CITES permit

The concept of CITES control based on a permit system has been designed in an era where the concept of the national border was very different than it is now. The permit was used for a limited number of easily recognizable species and with a limited number of annotations.

Border inspection

The main type of intervention expected to control the trade is the border inspection by Customs Officers. In Canada the role of inspectors has changed over the years and the actual physical inspection is less than 5 % of the import and very limited at exportation.

Paper audit

Canada is presently experimenting the use of paper audit to identify potential smugglers. Customs auditors are reviewing for some products or importers all the paper work required for international trade and compare the declaration form, the tax form, the bill of lading, the invoice, the CITES and other permits. The initial results from a pilot project are amazing. For the products selected the rate of inaccuracy was extremely high. This type of analysis is time consuming and a good targeting is essential to be effective.

Intelligence

Intelligence analysis is the key to identify areas to be inspected and audited. It is a long and complex operation which, if well done, clearly define what is important and reduce significantly the efforts placed in areas of less concern.

ISSUES

Dealing with control of international trade in ivory and elephant products is more difficult than we can expect. It is particularly true since there is a ban on trade because most of the traffic has been driven underground. Among other the following issues are adding to the difficulty: Ivory is easy to conceal, HS codes allow ways to not identify ivory, it is very difficult to identify ivory and fake products if they are in small pieces, presence of exemptions allowing some movement of ivory.

SOLUTIONS

There is no single solution to address all the issues and make the illegal trade under control. Some improvement could be done in:

- ensuring that HS codes are clearly showing the presence of ivory
- Increasing the exchange of intelligence on illegal trade through a formal working group and electronic communication
- more coordinated work to simplify identification of ivory products and fake ivory using Internet as a mean of communication
- creation, under the authority of the CITES Secretariat, of a chat line with limited access to officers involved in the control of elephant products.

Current challenges to elephant conservation in Kenya

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EXECUTIVE SUMMARY

Kenya's elephants are an important national asset. Wildlife tourism is one of the country's major sources of foreign exchange, and elephants are one of the most important elements in wildlife tourism. The status of Kenya's elephants has always been controversial. During the 1970s and 1980s it is estimated that Kenya lost over 80% of her elephants due to infamous poaching for ivory.

Threats facing Kenya's elephant populations differ across the country

- Kenya's major forest populations of Mt Kenya, Aberdares, Shimba Hills and Mt Elgon are at present not threatened by poaching. The greatest threats to these populations come from conflict with surrounding communities, encroachment of human settlement and agriculture, habitat loss and changing land-uses. These populations are becoming increasingly isolated; former migratory routes have been cut-off by human settlement and local communities have cultivated adjacent to the forest boundaries.

- Land-use changes pose a threat to the Mara and Amboseli elephant populations. The Maasai pastoralists have adopted a more sedentary way of life and recent expansion of large-scale farming has reduced the elephant range. Both of these populations are relatively secure from poaching at present, this is as a result of a combination of factors including high tourism, presence of resident researchers and a buffer zone provided by the surrounding Maasai communities.

- In Kenya's northern and Tsavo populations, poaching has increased over the last 2-3 years. The situation of elephants in these areas has become more precarious with an increase in the number of firearms in the hands of the local communities. Banditry has increased over the last few years and with this has come an upsurge in the level of poaching. The local communities in these areas are heavily armed and have the potential to turn to large-scale elephant poaching should the incentive for ivory increase. The KWS readily admit that with the current resources and manpower they could not contain the poaching should it intensify.

Geomorphology and stratigraphy of the Ambrona site (central Spain)

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SUMMARY: The Ambrona archaeological site, which lies at the bottom of a senile anticlinal polje of Iberian structural direcction NW-SE, is represented by several stratigraphic members (AS1 to AS6) of the Lower Complex, composed of fluvial and lacustrine deposits. The site was formed before the southern capturing of the polje by the Masegar river, an affluent of the upper Jalón river. Geomorphologic analysis of the subsequent polycyclic development of the Masegar valley indicates that Ambrona and Torralba occupy chronologically different positions and that Ambrona is older than the Torralba site. The age of Ambrona is estimated to be older than 350 ka, once its position is correlated with dated travertine terraces of other fluvial valleys in the area.

1. INTRODUCTION

The Lower Acheulian site of Ambrona (Fig. 1A)–like the Torralba site 2.5 km south–occupies a singular position in the NW Iberian Range due to its relation with an Tertiary and Quaternary karstic landscape and with three large hydrographic basins of the Iberian Peninsula: those of the rivers Duero and Tajo (both Atlantic) and the Ebro-Jalón Mediterranean basin. Since the Lower Pleistocene, the river Jalón and tributaries draining the upper basin, have captured the headwater areas of the Tajo and Ebro valleys, due to their lower position base level.

2. GEOLOGY AND GEOMORPHOLOGY

Outcropping materials in the immediate surroundings of Ambrona, are continental and marine deposits Triassic in age, in their Germanic Buntsandstein (conglomerates and sandstones), Muschelkalk (dolomites and limestones) and Keuper (marls, limestones and gypsums) facies. Top beds are composed of carbonate deposits corresponding to the transition to the Jurassic comprising of the Formations Dolomías tableadas de Imón and Carniolas de Cortes de Tajuña, along with other limestone units of the Upper Lias. The Cretaceous (Albian-Coniacian) is preserved to the NW of Ambrona in the syncline of La Ventosa del Ducado, and composed by sands, gravels, limestones and dolomites.

From a geomorphological point of view, the sites of Ambrona and Torralba have been related to the development of the Conquezuela-Ambrona-Torralba anticlinal polje (Pérez-González *et al.* 1997). Three general erosion surfaces were recognised, the oldest (M3, dated Miocene) and topographically highest, lies at an altitude of 1200 m. The most relevant process occurring during the Lower Pleistocene was the chemical and physical degradation of the M1 surface (1150 m). Weathering residues were drained by the Bordecorex river (Duero tributary), whose southern watershed possibly followed the Torralba village parallel, about 5 km south of its current position.

Denudation of the carbonate M1 surface led to the development of an erosion level, which coincides with the stratigraphic contact

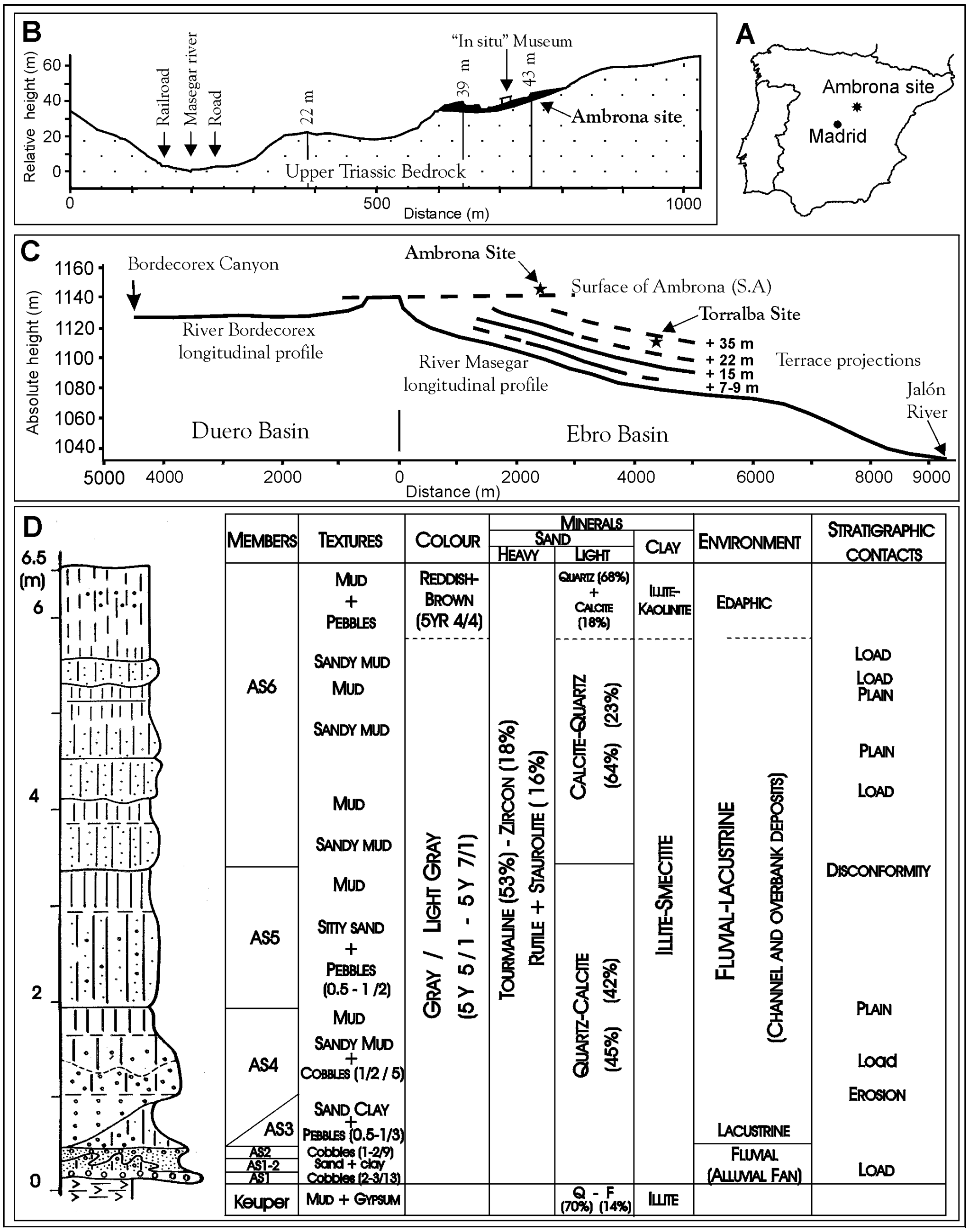


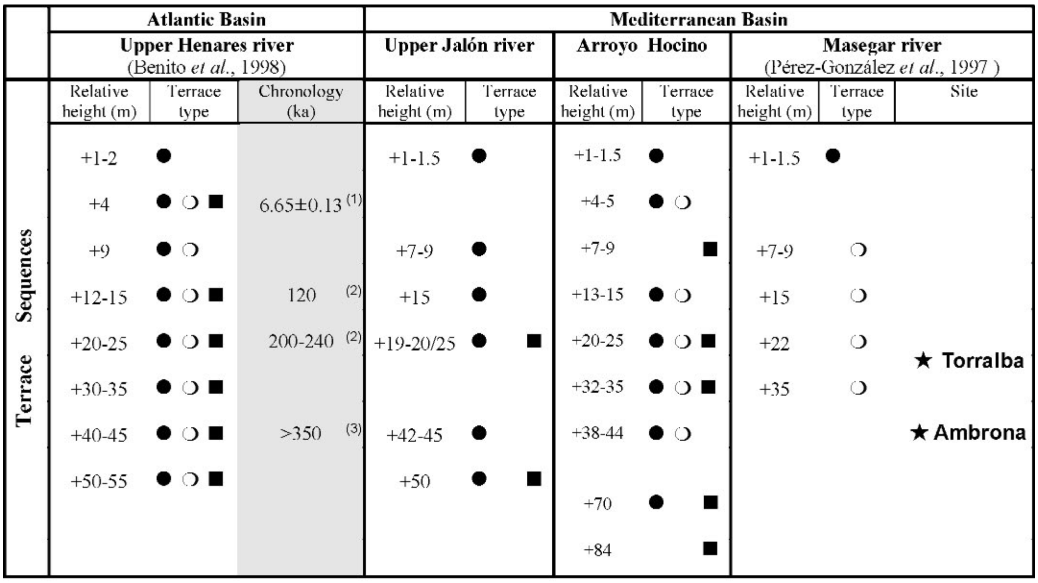
Fig.1 - Ambrona site in its geographical (A), geomorphological (B and C) stratigraphic context (D). In figure D, gravels in cm (mode/larger). Minerals: Q (quartz), F (feldspar).

between the Keuper facies and the dolomite Upper Triassic unit of the Imón Formation.

This level of local erosion at about 1140 m is known as the Surface of Ambrona (SA). The Middle Pleistocene saw the accumulation of alluvial fans and lacustrine-like deposits in Ambrona, associated with fauna and early Acheulian industry. In this setting of relative stability, the Masegar tributary of the Jalón river began its new course, capturing the valley of the Bordecorex river and progressing towards the current watershed, to the North of the village of Ambrona. This process left the Ambrona site at a relative height of 39-40 m above the channel bed of the Masegar river, at an absolute altitude of 1145 m (Fig. 1B). The development of the Masegar river valley has followed a polycyclic pattern, with bed-rock terraces at +7-9 m, +15 m, +22 m, and +35 m, and an alluvial plain at 1 m. The Acheulian site at Torralba (Fig. 1C) occupies an intermediate morphological position between the terraces at +35 m and +22 m. It lies about 6-7 m into the +35 m terrace, with its bottom 28 m above the floodplain of the Masegar river, at an absolute height of 1115-1116 m. This means that the Torralba site is younger than the Ambrona site and, therefore, they fail to show the same stratigraphic formation.

3. LITHOSTRATIGRAPHIC AND CHRONOLOGICAL APPROACHES

Previous stratigraphic works (Butzer 1965, Howell *et al.* 1995) established two lithostratigraphic units, defined as the Lower and Upper Member Complexes. In the present paper, we only refer to the stratigraphy of the Lower Member Complex, which provisionally includes the top unit AS6, according to the stratigraphic division proposed by Pérez-González *et al.* (1999). Investigations underway will define a new informal Ambrona



	Atlantic Basin			**Mediterranean Basin**						
	Upper Henares river (Benito *et al.*, 1998)			**Upper Jalón river**		**Arroyo Hocino**		**Masegar river** (Pérez-González *et al.*, 1997)		
	Relative height (m)	Terrace type	Chronology (ka)	Relative height (m)	Terrace type	Relative height (m)	Terrace type	Relative height (m)	Terrace type	Site
Terrace Sequences	+1-2	●		+1-1.5	●	+1-1.5	●	+1-1.5	●	
	+4	● ❍ ■	6.65±0.13 (1)			+4-5	● ❍			
	+9	● ❍		+7-9	●	+7-9	■	+7-9	❍	
	+12-15	● ❍ ■	120 (2)	+15	●	+13-15	● ❍	+15	❍	
	+20-25	● ❍ ■	200-240 (2)	+19-20/25	● ■	+20-25	● ❍ ■	+22	❍	★ Torralba
	+30-35	● ❍ ■				+32-35	● ❍ ■	+35	❍	
	+40-45	● ❍ ■	>350 (3)	+42-45	●	+38-44	● ❍			★ Ambrona
	+50-55	● ❍ ■		+50	● ■					
						+70	● ■			
						+84	■			

Fig.2 - North-occidental Iberian Range fluvial terrace correlations and morphological and chronological position of Ambrona and Torralba. Chronologies according to: (1) Gladfelter (1971), (2) Howell *et al.* (1995), (3) Ordónez *et al.* (1990).

Terrace type: = gravel, sand and mud, < travertine, ❍ bed-rock.

Formation, composed of three member complexes (Pérez-González *et al.*, in prep.).

The lithostratigraphy of Ambrona presented in Figure 1D, corresponds exclusively to the central site area. In this sector, it is possible to define a stratigraphic column of about 6.5 m that has been subdivided into six members: AS1 to AS6. All the facies described in Figure 1D correspond to fluvial or shallow lacustrine environments. From AS1 to AS2, gravels, sands and clays facies, derived from the NE (AS1) or E (AS1/2-AS2) represent medial or distal positions of alluvial fans, in which individual fluvial channels may be identified in AS1. AS3 deposits indicate a less energetic, shallow lacustrine environment, with limits W and NW of the site. AS3 contains abundant Elephas fauna and artefacts. The fluvial-lacustrine deposits of AS4 erode the top of AS3, with coarse material derived from the NE, deposited at the stream mouth. Like AS5, AS4 is a fining-upwards succession. AS6 overlies AS5 presenting a stratigraphic discontinuity and is formed by the regular interbedding of two alternating lithologies with abundant gastropods. The top of the sequence is formed by a soil, of vertic type with A, Bw, and 2Cg horizons.

Faunal and Acheulian artefacts indicate middle Pleistocene age. Geomorphological correlations with travertine terrace sequences of the upper Jalón and upper Henares valleys, indicate that Ambrona is older than the terraces at +20-25 m, aged ca. 200 ka (Howell *et al.* 1995). Moreover, given its geomorphological position prior to the construction of the +30-35 m terrace, it must be over 350 ka old, although at present it is not possible to establish its age with greater precision.

4. CONCLUSIONS

Excavations and detailed geomorphological analyses performed from 1993 to 2000 have provided a picture of the morphostratigraphic development of the Ambrona site and its surroundings. The lower stratigraphic levels of Ambrona are consistent with a sequence of fluvial and lacustrine materials derived from near-by carbonates slopes of the Upper Triassic and Lower Jurassic. Moreover, Ambrona represents a cultural and environmental milestone of the last developmental stages of a morphostructural-karstic corridor, 15 km in length and 1 km wide, which interlinks Atlantic and Mediterranean basins. Further, the site is older than the capturing of this corridor by the Masegar river, a left bank affluent of the river Jalón. Ambrona may be broadly correlated with terraces at a relative height of +40 m above present channels that have been dated as over 350 ka.

5. REFERENCES

Benito, A., Pérez-González., A., Santonja, M.1998. Terrazas rocosas, aluviales y travertínicas del valle alto del río Henares (Guadalajara, España). *Geogaceta* 24: 55-58.

Butzer, K.W. 1965. Acheulian Occupation Sites at Torralba and Ambrona, Spain. Their Geology. *Science* 150: 1718-1722.

Galdfelter, 1971. *Meseta and campiña landforms in Central Spain. A geomorphology of the Alto Henares Basin.* Research Paper 130. Univ. of Chicago.

Howell, F.C., Butzer, K.W., Freeman, L.G., Klein, R.G. 1995. Observations on the Acheulean occupation site of Ambrona (Soria Province, Spain), with particular reference to recent investigation (1980-1983) and the lower occupation. *Jahrbuch des Römisch-Germanischen Zentralmuseum Mainz* 38: 33-82.

Ordónez, S., González, J.A., García del Cura, M.A. 1990. Datación Radiogénica (U-234/3-238 y Th-230/U-234) de sistemas travertínicos del Alto Tajo (Guadalajara). *Geogaceta* 8: 53-56.

Pérez-González, A., Santonja, M., Gallardo, J., Aleixandre, T., Sesé, C., Soto, E., Mora, R., Villa, P. 1997. Los yacimientos pleistocenos de Torralba y Ambrona y sus relaciones con la evolución geomorfológica del polje de Conquezuela. *Geogaceta* 21: 175-178. Madrid.

Pérez-González, A., Santonja, M., Mora, R., Soto, E., Sesé C., Ruíz Zapata, M.B., Aleixandre, T., Villa P., Gallardo, J. 1999. Investigaciones recientes (1990-1997) en los yacimientos achelenses de Ambrona y Torralba (Soria, España). Aproximación al Complejo Estratigráfico Inferior de Ambrona. *O Arqueólogo Português*, 13/15 (1995-1997): 11-34.

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Lithic artifacts from the lower levels of Ambrona (Spain) - taphonomic features

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SUMMARY: The present report discusses the main features and the nature of the stone artifact assemblages from Ambrona, based on their stratigraphic provenience, raw material, edge rounding, size and general assemblage composition.

1. INTRODUCTION

Excavations undertaken over the last few years (1993-2000) have provided a more precise and detailed understanding of the depositional context of stone and bone remains found at Ambrona. In the past, lithic artifacts of the lower levels have been related to the presence of fauna, particularly Elephas, and published only in general terms (Howell *et al.* 1995).

In this paper, we analyze the Ambrona artifacts by stratigraphic units (Pérez-Gonzáles *et al.* 2001; Soto *et al.* 2001; Villa *et al.* 2001). These units in combination correspond to the so-called "Lower Member Complex" of Howell *et al.* (1995). It was in this complex that F.C. Howell (1961-1963 and 1983), E. Aguirre (1973), and F.C. Howell and L.G. Freeman (1981-1982) excavated some 2088 m^2 and recorded 1388 lithic pieces whose precise strati-

Tab.1 - Stone artifacts by level (1993-2000).
Artifacts showing no signs of edge rounding (edge rounding = 0) in AS3 are in parentheses.

	AS1	AS1/2	AS2	AS2/3	AS3	AS4	AS5
Non-cortical flakes	25	1	6		11 (6)	76	1
Non-cortical flake fragments	39	2	3		13 (1)	83	1
Cortical or partly cortical flakes	23				6	24	
Cortical or partly cortical flake fragments	14		1		3	27	
Tools on non-cortical flake	25	6		1	13 (4)	41	2
Tools on cortical flake	19	1			4	10	
Cores	19				4 (1)	15	
Cores on flake	2				2 (2)		
Retouched cores	1					3	
Chunks	40	3	4	1	10 (2)	56	2
Small tools on pebble	4					1	
Choppers	6					1	
Modified pebbles	1						
Hammers	8				4 (?)	1	
Bifaces	5				2 (2)	1	
Biface fragments	1						
Flake cleavers and similar pieces	2	1					
Trihedrals	1						
Total : 682	235	14	14	2	72	339	6

graphic position remained undescribed (Howell *et al.* 1995).

Knowledge of the stratigraphic context of these pieces is a key factor in defining sets of artifact of similar age and for understanding the accumulation processes of each aggregate. Besides the stratigraphic position, our analysis considers certain basic characteristics such as general assemblage composition, artifact size, edge rounding and raw materials.

2. EXCAVATED AREAS

During the period 1993 to 2000, 630 m^2 of the central and western sector of the site were excavated. The total number of pieces found in this area is 682. The artifacts were unevenly distributed throughout the levels AS1 to AS5, and are more abundant in levels AS1, AS3 and AS4 (Tab. 1). The total density slightly exceeds 1 piece per square meter; it was given as 0.7 in previous excavations, though these numbers are of little significance since each level is an independent sedimentary and chronological unit. In the central sector level AS6 was removed prior to 1993. AS5 and AS6, excavated in the southern sector of the site in 1993, were sterile. Only very few stone artifacts were found in level AS5 of the northern sector (Tab. 1).

The area excavated in each level is provided in Table 2. Levels AS1, AS4 and AS5 covered the entire site surface, while AS1/2, AS2, AS2/3 and AS3 occupied more limited sectors. In AS4, artifacts were found only in the detrital facies. In AS1 only 35 m^2 were completely excavated (from top to bottom of level); in the rest of the site, the excavation stopped when the top of this level was reached. The main faunal sets (the majority from AS3) have been left in situ. Thus 50 m^2 of the levels below AS3 have not been excavated.

3. RAW MATERIALS

The Ambrona stone artifacts were made on different varieties of flint and silicified limestone (here treated together as “flint”), of quartzite, quartz and limestone. With the exception of the latter found in nearby outcrops of the Upper Triassic and Jurassic beds (Imón Formation), all other raw materials are allochthonous and were introduced by man, as indicated by Freeman (1991). The Buntsandstein conglomerates of Miño, 4,5 Km away, are the closest source of quartzite clasts. To the SW of Miño, there is a relative abundance of quartz in the Cretaceous basal facies of Ventosa del Ducado, while flints are found further away. All levels with a substantial number of artifacts (Tab. 3) show similar lithology, with a slight predominance of quartzite over flint or even quantities of both and a minor but constant frequency of quartz and limestone. The assemblage formed by the unabraded pieces of AS3 differs by showing a clear predominance of flint, although the sample size is small.

Note that stone hammers, cores and knapping byproducts – from cortical flakes to small debris generated by tool retouch – occur in all raw materials at least in the AS1 and AS4 assemblages (Tab. 1). All the debitage phases are documented. The incidence of cortical items (not just hammers) suggests the introduction of blanks or blocks of raw material for knapping.

4. DENSITY AND SOURCE OF ARTEFACTS IN EACH LEVEL

- Level AS1. Nearly 80% of the artifacts of this occupation appeared in the 35 m^2 excavat-

Tab.2 - Areas excavated in each level (1993-2000).

Level	AS1	AS1/2	AS2	AS2/3	AS3	AS4
Area excavated (m^2)	580 upper 35 tot.	195	195	ca 2	250	630 total 379 detrital facies

Tab.3 - Raw materials.

Raw materials (%) Level	Flint	Quartzite	Quartz	Limestone
AS1 (N=182)	34.1	52.7	9.3	3.8
AS1/2 (N=14)	50.0	50.0	0	0
AS2 (N=14)	21.4	57.0	21.4	0
AS3 (N=72)	40.3	45.8	8.3	5.6
AS3, R=0 (N=18)	72.2	27.8	0	0
AS4 (N=339)	46.6	43.1	7.4	2.9

Tab.4 - Edge rounding.

Edge rounding (%) Level	R0 null	R1 moderate	R2 strong	R>2 very strong
AS1 (N=226)	3.1	56.6	34.3	6.3
AS1/2 (N=14)	0	71.0	29.0	0
AS2 (N=14)	0	35.7	57.1	7.1
AS3 (N=68)	26.5	38.2	32.4	2.9
AS4 (N=339)	5.3	68.0	21.0	5.6

ed in the northern sector. The remaining 53 pieces were derived from its exposed top surface (545 m^2). The density of items in the first of these sets was 5.2/m^2 (around 6.5/ m^3). This value is notably lower than that registered at other sites, in fluvial deposits of the Middle Pleistocene of the Meseta (40/ m^3 in Pinedo and Cuesta de la Bajada, 120/ m^3 in La Maya I; on the surface of comparable gravel levels in Cuesta de la Bajada, the density was 2 per m^2, while on the AS1 surface it is 1/10 m^2). The ratio flake/blank in AS1 (3.7:1) was, nevertheless, similar to that recorded at the above-mentioned sites (5:1 in La Maya I and 4:1 in Pinedo; Santonja 1986; Santonja *et al.* 2000).

The AS1 assemblage is clearly abraded (Tab. 4). The few fresh pieces (R = 0) occurred mostly in clay lenses. The artifacts appear to have undergone transport and their mean dimensions (Tab. 5) confirm this, which are of the same order as the gravels forming the AS1 level. This transport must have occurred over short distances since the slope drained by the transporting channels is very close and the flake/blank ratio is not excessively unbalanced.

- Level AS3. The excavated area of 250 m^2 has produced 72 stone artifacts with clear signs of edge rounding and fluviatile transport related to the detrital clasts that reach this level. Eighteen, or 25%, of the pieces show completely unabraded edges, suggestive of primary context; these pieces may be associated with the fauna of this level. Despite their small number, it should be noted that in addition to two bifaces there were several non-cortical flakes with little retouch, mostly made of flint and generally larger in size than the site mean (Tabs. 1, 3 and 5).

- Level AS4. This is the largest assemblage, yet it shows a lower density of artifacts than AS1, that since it does not exceed 1/m^2 (1 to 2/m^3) over the 379 m^2 excavated in the detritic facies. The flake/blank ratio is high (13/1), but if we take into account the high proportions of slightly rolled to rolled pieces (Tab. 4) and their size - the smallest recorded at Ambrona (Tab. 5)

Tab.5 - Size of stone artifacts.

Size (mm) Level	N	Max. – Min.	Mean
AS1	235	223 - 08	37.8
AS1, hammers and modified pebbles excluded	226	223 - 08	37.0
AS 1-2	14	89 - 19	40.5
AS2	14	53 - 12	24.1
AS3, excluding stone hammers	68	125 - 08	36.7
AS3, only R=0	18	125 - 14	54.6
AS4	339	134 - 03	24.8
AS4, excluding bifaces and choppers	337	69 - 03	24.2

- it appears that clear selection by size took place in the transporting medium. The origin of this assemblage must be sought at the periphery of the preserved site. The absence of artifacts in the less detritic facies of AS4 should be noted; it suggests that those in the rest of the level could be derived from the erosion of former deposits including those of AS1.

- Levels AS1-2, AS2, AS2-3 and AS5. These show a very small number of lithic pieces. Like AS1, AS1-2 and AS2 are fluvial levels, but represent distal facies from the E and SE of greater length than the northern channels that gave rise to AS1. These transported artifacts occur at a low density in the Ambrona area, less than 1 piece per 10 m^2, but reflect human activity in the S and E of the preserved site, with raw materials resembling those of AS1. The scarcity of lithic artifacts in AS5 (only 6) could suggest a secondary position for these materials.

AS2-3 is clay facies of the AS2 level and is only distinguishable in the most southern sector. Its only interest seems to be in that it bears witness to the continuity of human presence throughout the lower stratigraphic units at Ambrona.

5. CONCLUSIONS

The density of lithic artifacts in Ambrona is relatively low and it is clear that they were partly introduced into the preserved site from nearby areas. There appears to be a direct relationship between the group of unabraded pieces in AS3 and the characteristic megafauna of Ambrona. This small series, with two bifaces and several flakes with minimally retouched cutting edges, may be distinguished from the pieces recorded in AS1 and AS4, where flake tools are more frequent.

Judging by the lithic industry, it might be stated that human presence in Ambrona was not intense during the time represented by the lower occupation levels. However, it would also seem that this was the case throughout the entire period, since the introduction of nonlocal raw materials into the site appears to be a consistently repeated feature.

6. REFERENCES

Howell, F. C., Butzer, K.W. ; Freeman, L.G. & Klein, R.G. 1995 Observations on the Acheulean occupation site of Ambrona (Soria Province, Spain), with particular reference to recent investigation (1980-1983) and the lower occupation. *Jahrbuch des Römisch-Germanischen Zentralmuseum Mainz* 38: 33-82.

Freeman, L.G. 1991: What mean these stones? Remarks on raw material use in the Spanish Paleolithic. In A. Montet-White, S. Holen (eds.), *Raw Materials Economy among Prehistoric Hunter-Gatherers*: 73-125. Lawrence: University of Kansas Press.

Pérez-González, A., Santonja, M., Mora, R.; Soto, E., Sesé, C., Ruiz Zapata, B., Aleixandre, T., Villa, P. & Gallardo, J. 1999: Investigaciones recientes (1990-1997) en los yacimientos achelenses de Ambrona y Torralba (Soria, España). Aproximación al Complejo estratigráfico inferior de Ambrona. *O Arqueólogo Português* 13/15: 11-34.

Pérez-González, A., Santonja, M. & Benito, A. 2001. Geomorphology and stratigraphy of the Ambrona site (central Spain). *This volume.*

Santonja, M.1986. Valgrande (Puebla de Yeltes, Salamanca): área de talla y sitio de ocupación del Paleolítico medio. *Numantia* 2: 33-85.

Santonja, M., Pérez-González, A., Villa, P.; Sesé, C., Soto, E., Mora, R., Eisenmann, V. & Dupre, M. 2000. El yacimiento paleolítico de Cuesta de la Bajada (Teruel) y la ocupación humana de la zona oriental de la Península ibérica en el Pleistoceno Medio. In *Scripta in Honorem Enrique A. Llobregat Conesa*: 79-101. Alicante: Institución Gil Albert.

Soto, E., Sesé, C., Pérez-González, A. & Santonja, M. 2001. *This volume.*

Villa, P., Soto, E., Pérez-González, A., Mora, R. 2001. Taphonomy at Ambrona: new perspectives. *This volume.*

Elephants and stone artifacts in the Middle Pleistocene terraces of the Manzanares river (Madrid, Spain)

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SUMMARY: We discuss several sites with isolated specimens of *Elephas antiquus,* all of them located in Middle Pleistocene terraces of the Manzanares river. The sites of San Isidro, Orcasitas and Transfesa are in the +25 / 30 m terrace while Arriaga IIa is located in the complex terrace of Butarque. These sites are compared to the well-known sites of Aridos in the nearby Jarama valley.

1. INTRODUCTION

The lower section of the Manzanares river, from San Isidro in the city of Madrid, to the confluence with the Jarama river, 22 km downstream, contains the greatest number of Paleolithic sites known in the Iberian Peninsula. These sites are mostly located in the lower and middle terraces deposits of the river. The Manzanares river can be considered as the classical region of Spanish prehistory because the identification of lithic tools associated with faunal remains began in 1862 with the fieldwork of Casiano de Prado in San Isidro (Prado 1864). From that year until the present day, different researchers have located additional assemblages practically throughout this sector of the the valley (Santonja & Villa 1990). The high deposit concentration is related to processes of synsedimentary subsidence that have affected the final portion of the Manzanares valley since the Middle Pleistocene (Pérez-Gonzalez 1971, 1980) and have produced great accumulations of sands and floodplain muds. In these deposits, 10 m thick or more from San Isidro onwards, faunal remains and stone artifacts have been preserved better than in the typical gravel terraces of other rivers in the Meseta or of the same Manzanares upstream of San Isidro (Fig. 1).

2. THE MANZANARES RIVER TERRACES

Upstream of San Isidro the Manzanares terraces appear in steps, with heights of +2/3 m, +10/13 m, +16/18 m, +30/32 m, +36/40 m (this level is doubtful), +54/57 m, +66/69 m, + 82/84 m and +90/94 m (Pérez-González 1980). Discontinuous remnants of the + 25-30 m San Isidro terrace have been recognized between this point and Villaverde Bajo. The systematic study of this approximately 9 km long section, which does not preserve levels higher than San Isidro, is at present difficult, due to growth of the city of Madrid in the last decades. According to observations made by Pérez de Barradas, Wernert and Royo in the 1920s (Royo 1929), downstream from San Isidro,

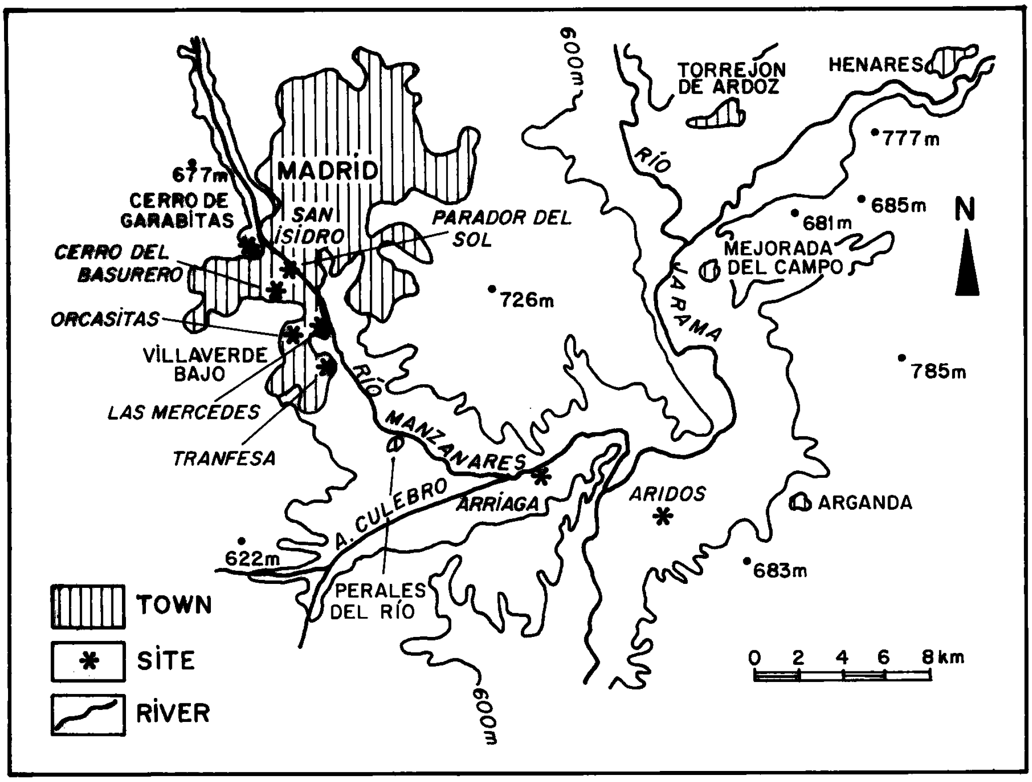

Fig.1 - Site location.

between the Toledo and La Princesa bridges (1500 m approximately), in addition to this terrace of +30 m there existed others at lower levels; their lowest gravel-bar layer rested on the Tertiary substratum, at +9/14 m, + 3/5 and + 1 m. The lowest terrace, which contained stone artifacts of Upper Palaeolithic type, was clearly observed toward the center of the sector, 400 m before La Princesa Bridge. Below, from Perales del Rio onward, the levels at + 12-15 m, +18-20 m and +25-30 m are not stepped, but overlapping terraces giving rise to the complex terrace of Butarque (Goy *et al.* 1989) whose base is below the current floodplain level.

3. Paleontological and Geological Framework

From the discovery of San Isidro up to the present, some faunal specimens have occasionally been found in the Manzanares river valley. Most of them are isolated remains with only generic identification (*Bos*, *Cervus*, *Equus*) and not very precisely located. The most recent study (Sesé & Soto 2000) makes possible to distinguish at least two significant associations: the first one related to the San Isidro terrace and the second one to the Upper Pleistocene deposits from the last sector of the valley. Both of them cannot easily be correlated to the terraces near San Isidro. The San Isidro’s faunal group is characterized by the presence of *Elephas* (*Palaeoloxodon*) *antiquus*, found at San Isidro, Transfesa, Orcasitas, Las Mercedes, Cerro del Basurero and Villaverde Bajo. *Praedama* sp., a megacerine, found only in Transfesa, presents some archaic character within the Middle Pleistocene and, according to Sese and Soto, might bring the cronology of this site, as well as the whole + 30 m. terrace, back to the Biharian-Toringian boundary which suggests OIS 11 to 13.

The Upper Pleistocene fauna which has been identified in the Arroyo del Culebro deposits of the Perales del Rio area, is characterized by species like *Megaceros* cf. *giganteus* and *Coelodonta antiquitatis* as well as by the absence of *Elephas antiquus*, whose presence, however, has been located in Parador del Sol's sand quarry, below San Isidro, and on the +9-14 m terrace (Royo 1929).

The +30 m terrace lithic industry can be described as Acheulean. On the lower levels, assemblages of younger aspect have been found and seem to belong to Upper Acheulean and Mousterian-like in a general sense (Santonja & Villa 1990), but it is necessary to closely revise these assemblages as well as the ones from the lowest levels, some of wich might belong to the Upper Palaeolithic.

4. Deposits with isolated Elephants

Elephant remains have been found a number of times in Quaternary deposits of the Manzanares. Occurrences of *Mammuthus primigenius* are not well established, although in the museums of Madrid there are some tusks with no precise provenience. Practically all the well-known and identifiable remains correspond to *Elephas (Palaeoloxodon) antiquus platyrinchus*, a subspecies endemic to the Iberian Peninsula and typical of the Middle Pleistocene (Sesé & Soto 2000). In addition to isolated bones, groups of bones belonging to a single individual, similar to the Aridos occurrences (Santonja & Villa 1990) have been found several times, all located in the +25-30 m terrace. They are old finds, therefore the available information is limited. Another similar deposit is that of Arriaga IIa, in the complex terrace of Butarque, excavated in more recent times.

4.1. San Isidro

The stratigraphic sections of San Isidro were about 15 m thick, showing gravel bars at the bottom and sands with gravel and clay layers above. At the top, also with sandy layers, there was a facies of probable lateral origin and the clay horizon of a red soil. During the middle of the 19th century (Paz Graells, 1897) grouped remains, though not in anatomical articulation, of two elephants were observed in a mud level. The two findspots were close, but independent. In one were observed at least the two tusks and a humerus, and in the other the pelvis, part of the jaw, a tusk and several long bones. In this level and in the lower ones, there were Acheulean artifacts (Santonja & Villa 1990), but their relation to the elephant remains was not clearly established.

4.2. Orcasitas

An excavation made in 1959 (Mazo 1994) provided the remains of an adult individual of *Elephas antiquus*, some 45-years old. Essentially it consisted of a skull with the two tusks in place, that lied in reverse position, resting on the occipital region. It rested on a layer of marls 80-cm thick, included in deposits of "marly sands" and under other of "clayey sands". Stone artifacts were not reported, but they occur in the same levels of the terrace.

4.3. Transfesa

The Transfesa quarry is also located in the +25-30 terrace. Thus remains of the two elephants, *Elephas antiquus*, found here in 1958 (Meléndez & Aguirre 1958) are of a similar chronology to those of San Isidro and Orcasitas. The remains were found on a gravel layer and were covered by marls and gravels. Acheulean tools are found in the same level, though the published observations do not permit to confirm their relationship to the faunal remains. According to Meléndez and Aguirre (1958), the deposit covered an area of 70x20 m, and the remains were somewhat dispersed. The larger elephant, an adult male 4,5 m tall, was represented by the right scapula, the left humerus (125 cm in length) the right ulna and radius, and the incomplete left femur. Of the other individual, a smaller male, were found the left humerus (118 cm long), the right ulna and radius in anatomical articulation, the left radius, the incomplete left femur, as well as one of the tibias and an indeterminate side fibula. The cranium was resting on its base and was complete, the vault something flattened, possibly by the weight of the sediments, with the four molars in the jaw. The bones appeared slightly altered, in part fissured by weathering. Some long bones were broken, but there is no information about these features.

4.4 Arriaga IIa

The Arriaga sand quarry (Rus & Vega 1984) is located in the complex terrace of Butarque. Its age, based on the micromammals of the unit IIa (Sesé & Soto 2000) is estimated near the end of the Middle Pleistocene, more recent than Aridos and San Isidro. The archaeological level is included in a fine sand deposit, lying over marls and muds that correspond to the consolidated surface of an ancient floodplain. The excavation, carried out in 1984, revealed the remains of *Elephas antiquus*, a female, adult in age but not senile: a cranium lying in inverse position, the two tusks, two upper molars, a mandible with M3, the right scapula, vertebrae and ribs, possibly associated with stone artifacts. The remains were concentrated in some 8 sq.m of the 56 sq.m excavated. The excavation also produced 43 stone artifacts: cores, bifaces, flake tools and débitage. Another relevant feature of the site was the occurrence of various hollows, some of fluvial and biological origin, but others, especially a circular hole, 25 cm in diameter and 26 cm deep, under the elephant remains, more difficult to explain by natural processes.

5. CONCLUSIONS

Deposits with occurrences of only one elephant seem frequent in the floodplains of the Middle Pleistocene Manzanares terraces. In San Isidro, Orcasitas and Arriaga the remains lie over paleosurfaces, and are covered by sandy deposits of channel facies, suggesting that smaller elements might have been displaced. The deposit described in Transfesa would occupy a different position, in an abandoned meander loop. At Arriaga IIa there seem to be associated stone artifacts, but that situation is less obvious in the other cases, especially at Orcasitas. The recorded findspots suggest a certain diversity of deposits, some with concentrated remains, in which the human intervention is clear (as is the case of Arriaga IIa, very similar to Aridos 2) and others (as Transfesa and San Isidro) with a greater dispersal of remains, perhaps comparable to Aridos 1, but of difficult interpretation with the available data.

6. REFERENCES

Goy, J.L., Pérez-González, A. & Zazo, C. 1989. *Cartografía geológica del Cuaternario, geomorfología y Memoria correspondiente de la Hoja a E. 1:50.000 de Madrid (559).* Madrid: Instituto Tecnológico GeoMinero de España

Mazo, A.V., 1994. El cráneo de *Elephas antiquus* (Proboscidea, Mammalia) de Orcasitas (Madrid). *Estudios de Prehistoria Madrileña,* 9: 17-23.

Meléndez, B. & Aguirre, E. de 1958. Hallazgo de Elephas en la terraza media del río Manzanares (Villaverde, Madrid). *Estudios Geológicos*, 23 (4): 597-605.

Paz Graells, M. de la. 1897. *Fauna mastológica ibérica.* Madrid: Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid.

Pérez-González, A. 1971. Estudio de los procesos de hundimiento en el valle del río Jarama y sus terrazas (nota preliminar). *Estudios Geológicos* 37: 317-324.

Pérez-González, A. 1980. Geología y estratigrafía de los yacimientos de Aridos en la llanura aluvial de Arganda (Madrid). In Santonja *et al.*, (eds.) *Ocupaciones achelenses en el valle del Jarama* 49-61. Diputación Provincial de Madrid.

Royo Gómez, J. 1929. *Cartografía geológica y Memoria de la Hoja Geológica a E. 1:50.000 de Madrid (559).* Madrid: Instituto Geológico y Minero.

Rus, I. & Vega G., 1984. El yacimiento de Arriaga II: problemas de una definición actual de los suelos de ocupación. *Primeras*

Jornadas de Metodología de la Investigación Prehistórica: 387-404. Ministerio de Cultura.

Santonja, M. & Villa, P. 1990. The Lower Palaeolithic of Spain and Portugal. *Journal of World Prehistory* 4 (1), 45-94.

Sesé, C. & Soto, E. 2000. Vertebrados del Pleistoceno de Madrid. In J. Morales (ed.), *Patrimonio Paleontológico de la Comunidad de Madrid*: 216-243. Madrid: Consejería de Educación de la Comunidad de Madrid.

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Elephants in the archaeological sites of Aridos (Jarama valley, Madrid, Spain)

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SUMMARY: Aridos 1 and Aridos 2 are archaeological sites of similar age in the Arganda I Formation, in the Jarama river valley (Madrid). Aridos 1- in primary context within low energy floodplain deposits - presents the disarticulated remains of an adult, female specimen of *Elephas antiquus*, in association with Acheulean lithic artefacts. Aridos 2 yielded part of an *Elephas antiquus* skeleton corresponding to an adult male also associated with Acheulean stone artefacts. The remains in Aridos 2 lie on the consolidated surface of a floodplain and were covered by river channel deposits that have partially eroded the site. Based on the Aridos 1 microfauna, these sites can be dated to isotope stages 9 or 11, with climatic conditions similar to the present.

1. INTRODUCTION

Aridos 1 and Aridos 2, excavated in 1976 (Santonja *et al.* 1980), are situated within the Arganda Formation I (Fig. 1). This formation, about 30 m thick, is part of a terrace sunken syndepositionally due to an underlying karst (Pérez-González 1971). Based on its relative position in the terrace system of the Jarama valley and correlations with other terrace systems of the central Iberian Peninsula, Arganda I has been dated as Middle Pleistocene (Pérez-González 1994).

The fauna found in this formation, especially the microfauna of Aridos 1 (López Martínez 1980), is considered to be of a younger age than Cúllar-Baza and older than the TD 10 and G II levels of Atapuerca, and represent climatic conditions similar to the present (Sesé & Sevilla 1996). According to chronological estimates proposed for Atapuerca (Pérez-González *et al.*, in press), the age of the Aridos sites might correspond to isotope stages 9 or 11.

2. ARIDOS-1

In Aridos 1, the remains of an adult female elephant - *Elephas (Palaeoloxodon) antiquus* (Soto 1980) - were found scattered over an area of some 50 m^2. They include the cranium and both jaw bones, both tusks, 12 vertebrae, parts of 9 or 10 ribs, both shoulder blades, the left pelvis and a metacarpal (Fig. 2).

Close to the elephant remains, 331 lithic pieces of flint and quartzite were found, all unabraded. Given that some of the pieces fitted together (60, or over 18%), these were interpreted as being derived from the knapping or shaping of 21 nodules or tools. Also, based on external features, some could be ascribed to the same block. At least three stone percussors and two bifaces were used at the site. The bifaces were actually transported away from the area but their presence is indicated by two-biface tip resharpening flakes. Most of the artifacts were flint flakes with natural or lightly retouched edges, and a few quartzite choppers.

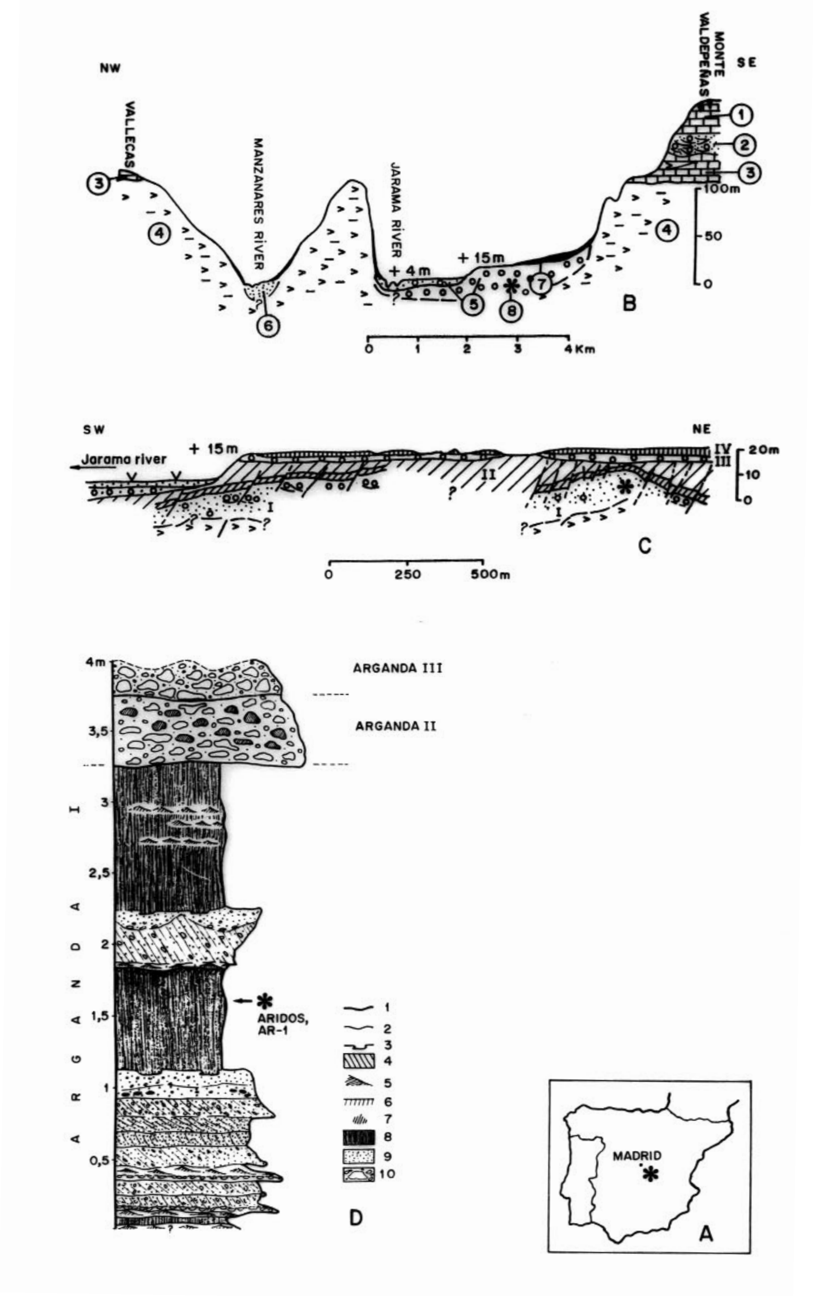

Fig.1 - Aridos site morpho-stratigraphical position in the synsedimentary sinking and inversion of the terraces of the Jrama river in Arganda. A: Aridos site SE of Madrid, central Spain. B: 1, limestones of the La Alcarria Paramo. 2, gravels and sands of intra-Miocene fluvial facies. 3 and 4, Miocene limestones, marls and gypsum. 5, sunken terraces of the Arganda alluvial plain and facies of gravels, sands and silts of the floodplain. 6, sands and clays of the sunken terraces of the river Manzanares. 7, Alluvial fans. 8, Lower Palaeolithic Aridos site. C: I, II, III and IV, relative geometry of sunken and overlapping alluvial deposits in the Aridos archaeological site. D: 1, unconformity. 2, erosive contact. 3, load structures. 4: fluvial sand dune. 5, ripples. 6, oxidation level. 7, Mn patches. 8, silt + sand + clay. 9, fine to coarse sand. 10, gravel, pebble to boulder.

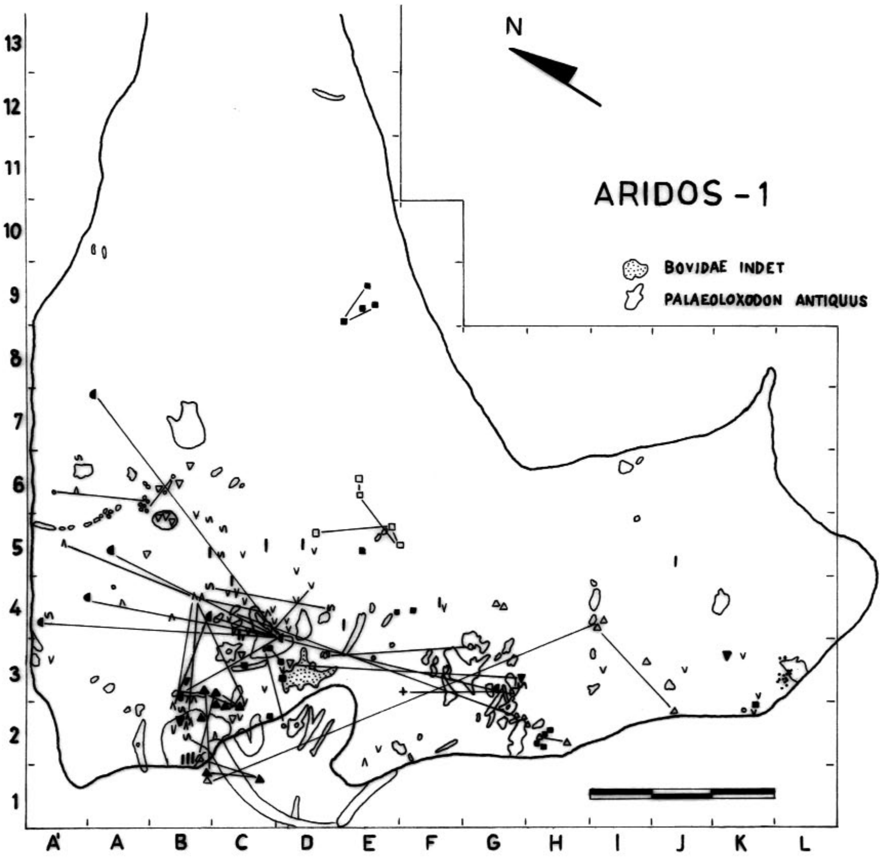

Fig.2 - Aridos 1: the excavated area.

The complex was interpreted as a typical butchering-site that has been fairly well preserved due to rapid covering by fine floodplain sediments (Santonja *et al.* 1980; Villa 1990; Santonja & Villa 1990).

3. ARIDOS-2

Aridos 2, which is close to the former site, is situated in a similar stratigraphic position within the Arganda I unit. The remains are deposited on the surface of an ancient floodplain. It is covered and partially eroded by river channel deposits of gravel and sand and is therefore not as well preserved as Aridos-1.

Before its discovery, the site was intensely affected by quarrying activities; thus, only 12 m^2 of the original surface were preserved.

In this second locality, the central part of the skeleton of an adult, male elephant – *Elephas (Palaeoloxodon) antiquus* – is preserved in anatomical connexion (Fig. 3): 24 cervical, dorsal and lumbar vertebrae and the ribs of the right side (Soto 1980). Quarrying activities destroyed most of the left ribs (only three remain). Thirty four associated lithic artefacts were found, including a biface and a cleaver.

4. CONCLUSIONS

Significant differences can be seen between the two sites. In Aridos 1, the skeletal remains of an adult elephant were found spread over a relatively small area – some 50 m^2 – that was partially preserved. These remains were clearly associated with lithic artefacts mainly related to knapping and resharpening activities conducted at the site. The entire complex was covered by

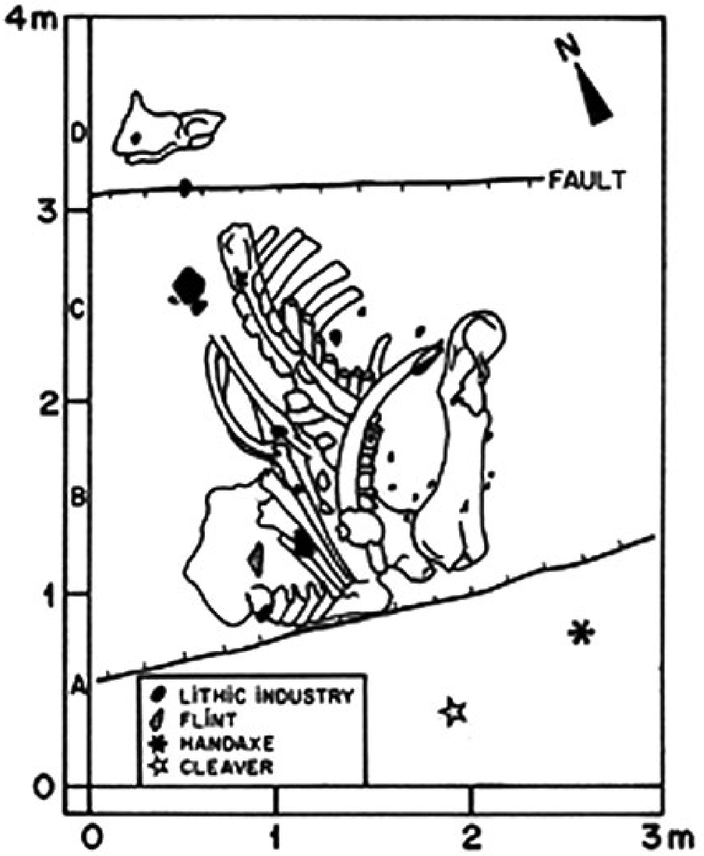

Fig.3 - Aridos 2: the excavated area.

fine sediments. It was therefore unaffected by hydraulic forces capable of displacing the remains, thus bone splinters and minute lithic debris wre preserved.

The partial skeleton preserved in Aridos 2 had not been dispersed, either as a consequence of human activity or of fluvial energy. The bones remained in anatomical articulation on a consolidated surface whose oxidation indicates a certain time of exposure to the atmosphere. A river channel established later in the area may have removed some of the associated lithic artefacts. A few of these, with unabraded or only very sligthly abraded edges, perhaps trapped by the bone remains, may be those identified in the excavation. Aridos 2 shows limited contextual integrity compared to Aridos 1, and although the exposed area is much smaller, it is obvious that human activities did not lead to a systematic dispersion of remains as it occurred at Aridos 1.

5. References

López Martínez, N. 1980. Los Micromamíferos (Rodentia, Insectivora, Lagomorpha y Chiroptera) del sitio de ocupación achelense de Aridos-1 (Arganda, Madrid). In M. Santonja *et al.* (eds.), *Ocupaciones Achelenses en el valle del Jarama*: 161-202. Madrid: Publicaciones de la Diputación Provincial.

Pérez-González, A. 1971. Estudio de los procesos de hundimiento en el valle del río Jarama y sus terrazas (nota preliminar). *Estudios Geológicos* 37: 317-324.

Pérez-González, A. 1994. Depresión del Tajo. In M. Gutiérrez Elorza (ed.), *Geomor-*

fología de España: 389-436. Madrid: Ed. Rueda.

Pérez-González, A., Parés, J. M., Carbonell, E., Aleixandre T., Ortega, A. I., Benito, A. & Martín Merino, M.E., in press. Géologie de la Sierra de Atapuerca et stratigraphie des remplissages karstiques de Galería et Dolina. *L'Anthropologie* 95.

Santonja, M., López, N. & Pérez-González, A. (eds.), 1980. *Ocupaciones achelenses en el valle del Jarama (Arganda, Madrid)*. Madrid: Publicaciones de la Diputación Provincial.

Santonja, M. & Villa, P. 1990. The Lower Palaeolithic of Spain and Portugal. *Journal of World Prehistory* 4 (1): 45-94.

Sesé, C. & Sevilla, P. 1996. Los Micromamíferos del Cuaternario español: cronoestratigrafía e implicaciones bioestratigráficas. *Revista Española de Paleontología, Número Extra*: 278-287.

Soto, E. 1980. Artiodáctilos y Proboscídeos en los yacimientos de Áridos de Arganda (Madrid). In M. Santonja *et al.* (eds.), *Ocupaciones Achelenses en el valle del Jarama*: 207-229. Madrid: Publicaciones de la Diputación Provincial.

Villa, P. 1990. Torralba and Aridos: elephant exploitation in Middle Pleistocene Spain. *Journal of Human Evolution* 19: 299-309.

Mammal fauna with *Elephas (Palaeoloxodon) antiquus* from the lower levels of Ambrona (Soria, Spain)

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SUMMARY: This paper deals with the fauna of macromammals from the lower levels "Lower Member Complex") of the Ambrona Middle Pleistocene site. *Elephas (Palaeoloxodon) antiquus*, remains are the most abundant in almost all the levels, varying between 28% and 38% of the total. Although elephants predominate, the Ambrona assemblage contains a very diversified fauna with at least nine different species.

1. INTRODUCTION

The site of Ambrona is situated in the province of Soria, in the north side of the Castillan branch of Cordillera Iberica (Iberian Range), in the Masegar (also called Arroyo de la Mentirosa) river valley. The Masegar is a left side tributary of Jalon river.

Elephant remains mentioned here come from the lower levels ("Lower Member Complex") of Ambrona (Santonja & Pérez-González 2000, in this volume), where the levels AS1, AS1/2, AS2, AS3, AS4, AS5 y AS6 were defined from bottom to top. (Pérez González *et al.* 1995-97).

The name of Ambrona, like the site of Torralba in the nearby, is associated to an archaeological settlement with plenty of elephant remains interpreted classically as a kill and butchering site since the beginning of the XX century (Cerralbo 1913), till Howell *et al.* (1995). We proposed that Ambrona is an elephant natural burial site, many remains have been transported while others remained *in situ* (Pérez González *et al.* 1995-97). Nevertheless, some of the animal remains appear to have been butchered or scavenged by man.

2. THE MAMMALIAN FAUNA

The micromammalian fauna of the Ambrona "Lower Member Complex" is *Crocidura* sp., *Microtus brecciensis* (Giebel 1847), *Arvicola* aff. *sapidus* (Miller 1908), *Apodemus* aff. *sylvaticus* (Linnaeus 1758) *Oryctolagus* sp. (Sesé 1986) The age defined by this fauna is of a typical or advanced Middle Pleistocene in the sense of Sesé & Sevilla (1996).

The identified macromammals from the recent excavations held by the authors from 1993 to 2000 are: *Canis lupus* Linnaeus 1758, *Panthera* sp., *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley 1847, *Equus caballus torralbae* Prat 1977, *Stephanorhinus hemitoechus* (Falconer 1868), *Capreolus* sp., *Cervus elaphus* (Linnaeus 1758), *Dama* cf. *dama* (Linnaeus 1758) and *Bos primigenius* Bojanus, 1827. The association of *Elephas (Palaeoloxodon) antiquus, Stephanorhinus hemitoechus*, *Equus caballus torralbae* and *Bos primigenius*), confirms the Middle Pleistocene age for Ambrona.

3. ANALYSIS OF THE MACROMAMMAL FAUNA

Elephant remains are undoubtedly predominant among all the macromammals remains. Nevertheless, the distribution of remains by species is very different among the levels. (Tab.1).

The most abundant and better preserved elephant remains are found in the levels AS3 y AS4. In 1995 was found in AS3 an assemblage of about 90 bones corresponding to an MNI of 3: one juvenile, one adult female and one adult male. The remains of the last one formed the so-called "concentration alpha", with almost a whole carcass: cranium, the whole mandible, both tusks, 17 vertebras and many ribs, both scapulas, the right humerus, ulna and radius of both sides, some carpal and metacarpal bones, the whole pelvis and a distal fragment of the right femur that could be related to the complete left femur found in the 1993 campaign and one tibia. Finally one fibula found in the 1993 campaign could correspond to this individual. In sum it would be there 3 individuals: the individual A determined exclusively by a cranial remain, the individual B by a male tusk and the individual C, an adult male to which belong all the above-mentioned remains.

This is a singular concentration because almost all the anatomic parts are represented, many of them in their anatomic natural position and some in connection, this indicates no or little transport. This kind of concentration has never been found in other areas of the site where the remains are more disperse and fragmentary.

The dispersion of the bones of the "concentration alpha" is similar to those of Shabi Shabi and specially to those of Nehimba described by Haynes (1991).

On the other hand, from a total of 1320 fossil specimens, the identification percentage varies between 42.47% in AS2 and 53.55% in AS1. That gives an idea of the fragmentation grade of the bones The last figure is very similar to the obtained by Cruz-Uribe & Klein (1986) and Howell *et al.* (1995) in the Lower Member Complex.

The best preserved faunal remains were found in the levels AS3 and AS4 associated with the more clayey facies. Meanwhile in the more detritic facies the remains are very fragmented and eroded (Villa *et al.*, 2001).

Regarding the Table 1, we can make the following considerations:

AS1 and AS2 are very detritic levels, thus the remains are more fragmentary than in others.

In AS1, 105 out of a total of 338 remains are of elephant, which represents 31.07%. The following best represented species is *Dama* cf. *dama* with 12 remains, that is: 3.55%. In this level was found the unique identifiable remain of rhinoceros: a mandible of *Stephanorhinus hemitoechus.*

In AS1/2, 14 out of 50 records are of elephant, that is 28%.

Tab.1 - Number of remains and percentage by taxa in each level.

LEVEL	AS1		ASI/2		AS2		AS3		AS4		AS5		AS6	
TAXA	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%
Canis lupus	0	0,00%	0	0,00%	0	0,00%	0	0,00%	3	0,79%	0	0,00%	0	0,00%
Panthera sp.	0	0,00%	0	0,00%	0	0,00%	1	0,22%	1	0,26%	0	0,00%	0	0,00%
Carnivora indet.	0	0,00%	0	0,00%	0	0,00%	1	0,22%	2	0,52%	0	0,00%	0	0,00%
Elephas antiquus	105	31,07%	14	28,00%	23	31,51%	175	38,04%	112	29,32%	2	33,33%	0	0,00%
cf. *Elephas*	3	0,89%	0	0,00%	0	0,00%	0	0,00%	4	1,05%	0	0,00%	0	0,00%
Equus caballus torralbae	6	1,78%	0	0,00%	1	1,37%	6	1,30%	8	2,09%	0	0,00%	1	100,00%
cf. *Equus*	1	0,30%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Dicerorhinus hemitoechus	1	0,30%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Capreolus sp.	0	0,00%	0	0,00%	0	0,00%	0	0,00%	1	0,26%	0	0,00%	0	0,00%
Cervus elaphus	6	1,78%	2	4,00%	1	1,37%	8	1,74%	2	0,52%	0	0,00%	0	0,00%
cf. *Cervus*	18	5,33%	0	0,00%	0	0,00%	6	1,30%	0	0,00%	0	0,00%	0	0,00%
Dama cf. *dama*	12	3,55%	1	2,00%	2	2,74%	8	1,74%	26	6,81%	0	0,00%	0	0,00%
cf. *Dama*	3	0,89%	1	2,00%	0	0,00%	2	0,43%	5	1,31%	0	0,00%	0	0,00%
Cervidae indet.	9	2,66%	3	6,00%	4	5,48%	18	3,91%	16	4,19%	0	0,00%	0	0,00%
Bovidae indet. cf. *Bos/Bison*	15	4,44%	0	0,00%	0	0,00%	4	0,87%	10	2,62%	1	16,67%	0	0,00%
Bos primigenius	2	0,59%	4	8,00%	0	0,00%	4	0,87%	2	0,52%	0	0,00%	0	0,00%
NID	157	46,45%	25	50,00%	42	57,53%	227	49,35%	190	49,74%	3	50,00%	0	0,00%
TOTAL	338	100,00%	50	100,00%	73	100,00%	460	100,00%	382	100,00%	6	100,00%	1	100,00%

In AS2, 23 out of 73 records are of elephant, that is 31.5%.

In AS3, 175 out of 460 records are of elephant, that is 38.04%.

In AS4, 112 out of 382 records are of elephant, that is 29.32%. It is worthwhile to mention that this is the only level where *Capreolus* sp. is represented by a single remain. It is remarkable that this is also the level that shows the highest faunal diversity, where almost all the taxa, except the rhinoceros, are present. This fact, added to the relative abundance of some species characteristic of temperate climatic conditions, as for instance *Dama* cf. *dama* and *Capreolus* sp, seems to indicate a relatively better climate.

In AS5 only 6 specimens were found and two of them are elephant remains.

In AS6 there is only one horse remain.

Elephant is, as the Table 1 shows, the most abundant species in each Lower Member Complex level from AS1 to AS5. Its NISP is near or above 30% of the NTSP in each level.

The following species most abundant by NISP are: *Dama* cf. *dama* and *Cervus elaphus*, both occur in each Lower Member Complex levels from AS1 to AS4. *Dama* cf. *dama* is the best represented cervid species at the site. The percentage of *Dama* cf. *dama* remains reaches 6.81% in AS4. *Bos primigenius* and *Equus caballus torralbae* are the following species in abundance.

Carnivores are sparse: *Panthera* sp. is represented by one remain in AS3 and other one in AS4 which could belong to the same individual; *Canis lupus* with three remains in AS4 and small carnivores non identified in AS3 and AS4.

3. CONCLUSIONS

The elephant, *Elephas (Palaeoloxodon) antiquus*, is the predominant species among the macromammals in all the levels of the "Lower Member Complex" at the Ambrona Middle Pleistocene site. Nevertheless, the macromammals assemblage of Ambrona is a very diversified fauna with two species of carnivores at least, one species of elephant, two perissodactyles and four artiodactyles. This variety, and the abundance of some species of cervids, indicates a relatively temperate climatic conditions, specially in some levels as the AS4 that shows the highest diversity. We suggest that the dispersion of the bones of the "concentration alfa", an almost complete carcasse of an adult male elephant, is similar to some actual concentrations of bones described in Africa (Haynes 1991).

4. REFERENCES

Cerralbo, Marqués de. 1913. Torralba, la plus ancienne station humaine de l'Europe?. *Congrès International d´Anthropologie et d´Archéologie Préhistoriques de Genève* XIV: 227-290.

Cruz Uribe, K. & Klein. R.G. 1986. Pascal programs for computing taxonomic abundance in samples of fossil mammals. *Journal of Archaeological Science*: 13: 171-187.

Haynes, G. 1991. *Mammoths, Mastodonts and Elephants. Biology, Behavior, and the Fossil Record*. Cambridge University Press.

Howell, F.C., Butzer, K.W., Freeman, L.G. & Klein, R.G. 1995. Observations on the Acheulean occupation site of Ambrona (Soria Province, Spain) with particular reference to recent investigations (1980-1983) and the lower occupation. *Jahrbuch des Römisch Germanischen Zentralmuseum Main* 38: 33-82.

Pérez-González, A., Santonja, M., Mora, R., Soto, E., Sesé, C., Ruiz Zapata, M.B., Alexaindre, T., Villa, P. & Gallardo, J. 1995-1997. Investigaciones recientes (1990-1997) en los yacimientos achelenses de Ambrona y Torralba (Soria, España). *O Arqueólogo Português* 13/15: 11-34.

Santonja, M. & Pérez-González, A. 2001. La industria lítica de los niveles inferiores de Ambrona. Aspectos tafonómicos. *This volume.*

Sesé, C. (1986). Insectívoros, roedores y lagormofos (Mammalia) del sitio de ocupación achelense de Ambrona (Soria, España). *Estudios geológicos* 42: 355-359.

Sesé, C. & Sevilla, P. 1996. Los micromamíferos del Cuaternario peninsular español: cronoestratigrafía e implicaciones biostratigráficas. *Revista Española de Paleontología, nº Extraordinario*: 278-287.

Villa, P., Soto, E., Pérez-González, A. & Mora, R. 2001. Taphonomy at Ambrona: new perspectives. *This volume.*

The Pleistocene elephants of Portugal

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SUMMARY: Elephants are present in Portugal since the Miocene. There are two kinds of stratification contexts with remains of Pleistocene elephants: geological and archaeological. We illustrate four archaeological sites. 1) Mealhada, a site located in the central region of Portugal, north of Coimbra. 2) Santo Antão do Tojal (Loures), a very important site in the Lisbon area on the right bank of the Tagus river. 3) Foz do Enxarrique (Vila Velha de Rodão), a site located in the upper Tagus near Spain. This site contains a single Mousterian level, that has the most recent dates for the presence of *Elephas antiquus*. 4) The cave site of Figueira Brava located near the city of Setubal on the south side of Arrabida mountain, where *Homo neanderthalensis* remains were found associated with bones, which have been attributed to *Mammuthus primigenius* with some caution.

1. INTRODUCTION

The Proboscidae are represented since very early times in the portuguese fossil record. In the Miocene, Mastodons and *Dinotherium* were very common in Portugal. Most of this evidence is from the Lisbon region. The permanence of elephants in our country continues in the Pliocene and is documented by a tusk fragment of a Mastodon found in the region of Santarém. In the Quaternary the presence of *Elephas antiquus* is recorded in the Pleistocene and some of this evidence comes from archaeological contexts. This paper will focus mostly on these archaeological sites.

2. THE SITES

2.1 Sites in a geological context

The sites with evidence of the presence of *Elephas antiquus* in Portugal can be divided in two types: sites in archaeological context, where the faunal evidence can be associated to lithic technology and sites in a geological context where these can be associated with evidence of other animal species.

Sites in a geological context: Condeixa-a-Velha and Conímbriga both in the Coimbra region. At the site of Condeixa, the molar of *Elephas antiquus* is from the fossiliferous Condeixa basal conglomerate correlated to the Mindel interstadial (Antunes & Cardoso 1992). In Conímbriga a tusk fragment was found during early excavations of the Roman city of Conímbriga done by Vergílio Correia.

The sites of Meirinha and Casal do Torcato are located in the Alenquer terraces, lower Tagus, where there is also another reference to evidence in this region. It is an elephant bone fragment slightly weathered and found in the Serviços Geológicos collections from the site of Casal do Campo, near the town of Carregado. The sediment that covered it presented the same characteristics of the sediment layer studied by Nery Delgado during his research done in the Carregado region (Zbyszewski 1943).

At the site of Casal do Torcato were found four molar fragments that are from the same tooth. All of them were found during the digging of a well (in a gravel and sandy bed with pebbles). This locality belongs to a lower terrace of the right bank of the Tagus river (12-15

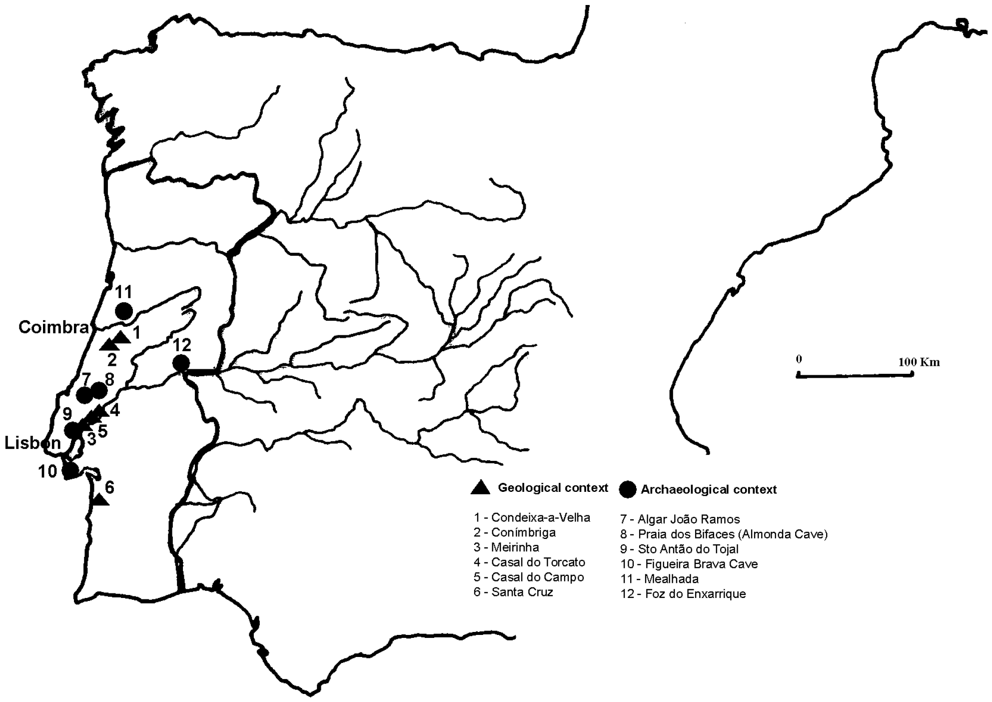


Fig.1 - Location map.

meters), that maybe ascribed to the last interglacial - Riss-Würm, Eemian (Antunes & Cardoso 1992).

The tusk from the site of Meirinha was found during the construction of the Northern Motorway and was integrated in the layer that corresponds to the deposits described earlier by Nery Delgado (Cardoso 1993).

The last site found in a geological context is Santa Cruz, situated on the Alentejo coast north of Sines Cape. Although the exact place, where the unciform of *Elephas antiquus* was found is unknown, it is probably from a site related most likely to Pleistocene deposits that outcrop in this region, mainly rosy sometimes brownish or red sands and gravels, lying upon Lias and Dogger formations (Antunes & Cardoso 1992).

2.2 Sites in an archaeological context

We will now present four sites with evidence of *Elephas antiquus* in an archaeological context: Foz do Enxarrique, Gruta da Figueira Brava, both recent excavations; Mealhada (excavated at the end of 19th century) and Santo Antão do Tojal found in the 1940´s.

There are still two other sites with an archaeological context: the site of Algar de João Ramos and the site of Praia dos Bifaces (handaxe beach) in Almonda Cave.

The site of Algar de João Ramos is a cavity situated in Serra dos Candeeiros near the village of Redondas (municipality of Alcobaça), the first reference to the existence of elephant bones in this area was made by Paul Choffat (Zbyszewski 1943). He described it as a fragment of a femur of a young elephant quite fossilised and with evidence of having been cut by lithic tools (Zbyszewski 1943). In this site a bone sample was collected and dated by ^{14}C and it obtained a date of 14,170 ± 330 BP (Antunes *et al.* 1989). Based on this date the elephant evidence was classified as *Mammuthus primigenius* since during this period *Elephas anti quus* had been extinct for some time and the only species surviving in Europe was *Mammuthus primigenius* (Antunes & Cardoso 1992).

In the report of the archaeological work done in the Almonda Cave (1988-89) the presence of a molar plate of *Elephas antiquus* was referred in an area called "Praia dos Bifaces" with an Acheulian lithic industry and a molar of *Equus caballus*. This site derived from the re-deposition of cone sediments formed inside the cave by the deposition of external human occupation material.

Four *Equus caballus* molars from different locals inside the cave including Praia dos Bifaces were dated by the method of Uranium series, and a preliminary date of about 150,000 years BP was obtained. (Zilhão *et al.* 1991)

2.2.1 Santo Antão do Tojal

This site is situated in the Várzea de Loures about 8 Km from Lisbon. In geological terms the terrace maybe contemporary of the beginning of the Last Glaciation, it is situated between 5-8m above the average level of the Tagus river. The stratigraphical studies revealed different sedimentary levels.

Here were found several bone fragments of *Elephas antiquus* in the construction work of a canal built by the Junta de Hidráulica Agrícola in the 1940's. In 1941 G. Zbyszewski found at the same place, a incomplete right femur that had in it two small flint flakes stuck inside. Also found was a proximal fragment of the right tibia that was in anatomical connection with the femur described above and several other bone fragments. In association with the elephant remains a Mousterian lithic industry was found along with other faunal remains. In a visit to the site thirty years later G. Zbyszewski, made a new discovery of a fragment of the same femur and a phalanx fragment.

2.2.2 Figueira Brava Cave

The first reference to this site was made in 1945 by G. Zbyszewski and H. Breuil. This cave is located near the city of Setúbal on the southern slope of the Serra de Arrábida. It was probably used as a rock-shelter during the middle Palaeolithic (upper Mousterian). The entrance is located at about 5 meters above the (present day) sea level and communicates with a large corridor that gives access to a large room. Archaeological work carried out between 1987 e 1990 in six archaeological excavations were directed by Teles Antunes and João L. Cardoso.

The stratigraphic sequence is made up of sands rich in shells and bone fragments brought in by man, and also stone implements dated from between 30 and 31 Kyr BP (^{14}C, U series) directly overlying marine Tyrrhenian III conglomerates. In the outer, exposed parts of the sands there are calcite consolidated into a hard breccia. A lithic industry and physical evidence (a phalanx and a tooth) of *Homo neanderthalensis* was found in association with a diversified faunal assemblage (Antunes & Cardoso 1992). In the 1988 excavation a molar plate fragment was found with very thin enamel. This fragment is intensely wrinkled. This characteristic led the authors of the study (Cardoso & Antunes 1989) to classify these as *Mammuthus primigenius* though with some caution. On the other hand the date obtained of about 30,000 and 31,000 BP which is 2000 years younger than the evidence from the site Foz do Enxarrique, reinforced this idea.

2.2.3 Mealhada

The site of Mealhada is located on the margins of Cértima tributary stream, of the Baixo Vouga river, about 12 Km North of the city of Coimbra. It was first discovered in 1876 and Carlos Ribeiro presented the site at the "Congrés International de Géologie" in Paris in 1878. He referred the existence of two tooth plates, and classified them with some reservation to *Elephas antiquus* (Fontes 1915).

Between 1879-1880 the site was excavated by Nery Delgado, he referred, that it produced some lithic material in a stratigraphic level. This layer upon a fossiliferous deposit was where some evidence of extinct large mammals had been identified (Ribeiro 1995-1997).

In the beginning of the 20th century Joaquim Fontes recognised the importance of the discovery, that was clearly differentiated from other sites for its clear integration in well defined stratigraphical sequence. He undertook the revision of the work done by Nery Delgado. He was able to reconstruct the stratigraphy of some of the wells excavated (three of six wells): The José Duarte, Dr. Adriano and the Dr. Costa Simões well. One of the wells was excavated right down to the jurassic substractum the horizontal galleries were also excavated. G. Zbyszewski who drew attention to the importance of the integration of this site in a terrace deposit contemporaneous of the Last Interglacial Riss-Würm (Zbyszewski 1940), classified the materials discovered there as being Acheulian and Mousterian industries, in a clear association with the fauna of large pleistocene mammals found. He correlated the site basal deposits as contemporaneous of the Mindel-Riss Interglacial. The palaeontological study identified the presence of *Elephas antiquus*, the faunal evidence revealed a molar fragment, a molar plate, two fragments of humerus, a fragment of a tibia, and four other bone fragments. G. Zbyszewski thought at that time, that the evidence was from an young specimen of *Elephas antiquus* (Zbyszewski 1943).

2.2.4 Foz do Enxarrique

The site of Foz do Enxarrique is located on the right bank of the Tagus river at the mouth of the Enxarrique stream, near the town of Vila Velha de Ródão, some 10 km from the spanish border. Large scale excavations have been conducted in the fluvial deposits of the Tagus, under the direction of L. Raposo since 1982. This research has revealed a single archaeological level with very rich lithic assemblage associated with a relatively small amount of bones and teeth from larger mammals. The Uranium-series dates on teeth provide a chronological frame for hominid activities at the site. The Mousterian level dates to a later phase of the Last Glaciation (initial Pleniglacial: transition OIS 2/3). This site corresponds to a more recent period of the Middle Palaeolithic dating to a later phase of the Last Glaciation and has a single archaeological level stratified in fine-grained sediments of the Pleistocene terrace sedimentary sequence.

This site has an assemblage associated with fauna in which the carnivores are almost absent. The lithic assemblage (mainly from quartzite and quartz), is characterised by numerous discoid and Levallois recurrent centripetal cores along with a high incidence of Levallois by-products, consisting mainly of flakes and where the entire reduction sequences are present. Methods of lithic procurement and transformation indicate an opportunistic and expedient technology.

In the faunal assemblage the elephant remains are represented by a complete, unworn plate from an upper molar and four bone fragments referred to *Elephas antiquus*. This find, indicates the survival of *Elephas antiquus* until the beginning of the latter part of the Last Glaciation (Wurm) and it is one of the last records of straight-tusked elephant known in Europe Burgal & Raposo 1999).

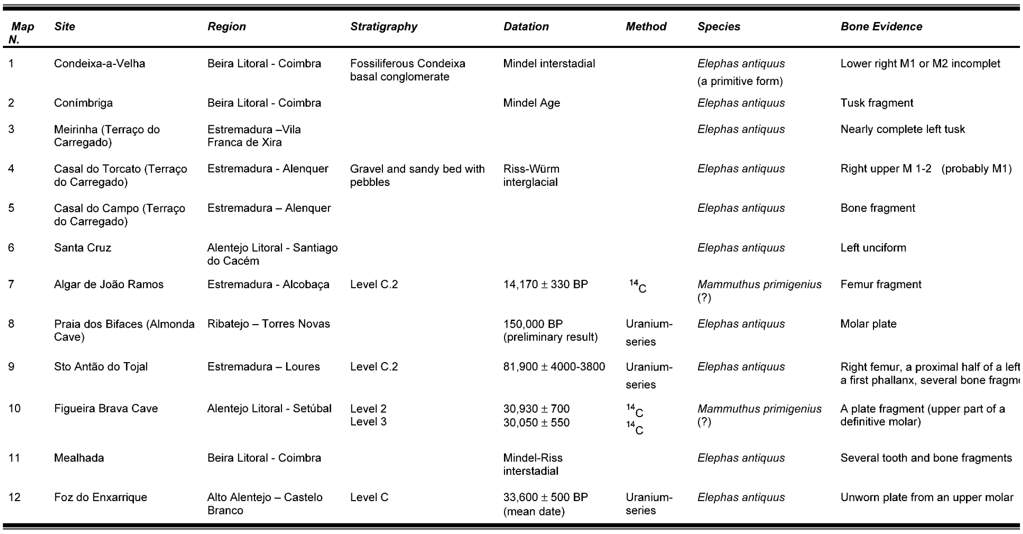
3. Conclusion

It is not possible to establish with our present data, the real importance of the elephant in the prehistoric populations subsistence strategies in Portugal. Although we can say that during thousands of years these large mammals were part of the natural environment in some regions of our country.

The species best represented is *Elephas antiquus* although there are some references at two sites for the existence of *Mamuthus primigenius*. This evidence is put forth with some caution. At the site of Algar de João Ramos, the femur bone found is very fossilized and has evidence of having been cut with a lithic tool (Zbyszwski 1943). The date mentioned for this site is about 14,000 BP, which excludes the *Elephas antiquus* species, but points to another species *Mammuthus primigenius*. Since the climate in this region was probably not favourable for the presence of these large mammals, the question of its identification is very cautious.

Based on the description made by G. Zbyszewsky it is very likely, that the femur bone may be a strange element in the stratum of the cave. It may have been introduced into the cave around the same time of the date obtained

Tab.1 - The Pleistocene Elephants of Portugal.



Map N.	Site	Region	Stratigraphy	Datation	Method	Species	Bone Evidence
1	Condeixa-a-Velha	Beira Litoral - Coimbra	Fossiliferous Condeixa basal conglomerate	Mindel interstadial		*Elephas antiquus* (a primitive form)	Lower right M1 or M2 incomplet
2	Conímbriga	Beira Litoral - Coimbra		Mindel Age		*Elephas antiquus*	Tusk fragment
3	Meirinha (Terraço do Carregado)	Estremadura –Vila Franca de Xira				*Elephas antiquus*	Nearly complete left tusk
4	Casal do Torcato (Terraço do Carregado)	Estremadura - Alenquer	Gravel and sandy bed with pebbles	Riss-Würm interglacial		*Elephas antiquus*	Right upper M 1-2 (probably M1)
5	Casal do Campo (Terraço do Carregado)	Estremadura – Alenquer				*Elephas antiquus*	Bone fragment
6	Santa Cruz	Alentejo Litoral - Santiago do Cacém				*Elephas antiquus*	Left unciform
7	Algar de João Ramos	Estremadura - Alcobaça	Level C.2	14,170 ± 330 BP	^{14}C	*Mammuthus primigenius* (?)	Femur fragment
8	Praia dos Bifaces (Almonda Cave)	Ribatejo – Torres Novas		150,000 BP (preliminary result)	Uranium-series	*Elephas antiquus*	Molar plate
9	Sto Antão do Tojal	Estremadura – Loures	Level C.2	81,900 ± 4000-3800	Uranium-series	*Elephas antiquus*	Right femur, a proximal half of a left a first phallanx, several bone fragm
10	Figueira Brava Cave	Alentejo Litoral - Setúbal	Level 2 Level 3	30,930 ± 700 30,050 ± 550	^{14}C ^{14}C	*Mammuthus primigenius* (?)	A plate fragment (upper part of a definitive molar)
11	Mealhada	Beira Litoral - Coimbra		Mindel-Riss interstadial		*Elephas antiquus*	Several tooth and bone fragments
12	Foz do Enxarrique	Alto Alentejo – Castelo Branco	Level C	33,600 ± 500 BP (mean date)	Uranium-series	*Elephas antiquus*	Unworn plate from an upper molar

References:
Antunes & Cardoso 1992 (1,2,3,4,5,6,7,9,10,11,12)
Zbyszewski 1943 (1,3,4,5,7,9,11)
Zilhão *et al.* 1991 (8)
Brugal & Raposo 1999 (12)

for this level which includes the femur bone.

In the Figueira Brava Cave, the assignment of the molar plate to a *Mamuthus primigenius* raises some doubts, because in our opinion it is most probable that this fragment of molar plate belongs to an *Elephas antiquus*, given the teeth of both species are very similar. We also present the survival of *Elephas antiquus* at Foz do Enxarrique, with a date of about 33,000 BP, which allows for the presence of this species until the beginning of the latter part of the Last Glaciation (Würm) and it is one of the last records of straight-tusked elephant known in Europe.

4. REFERENCES

Antunes, M.T. & Cardoso, J.L. 1992. Quaternary elephants in Portugal: new data. *Ciências da Terra* 11: 17-37.

Breuil, H. & Zbyszewski, G. 1943. Le Quartenaire de Santo Antão do Tojal. *Comunicações dos Serviços Geológicos de Portugal* 24: 43-70.

Brugal, J-P. & Raposo, L. 1999. Foz do Enxarrique (Ródão, Portugal): Preliminary results of the analysis of a bone assemblage from a Middle Palaeolithic open site. *Monographie des Römisch-Germanischen Zentralmuseums* 42: 367-379.

Cardoso, J.L. 1993. *Contribuição para o conhecimento dos grandes mamíferos do Plistocénico Superior de Portugal*. Oeiras: Câmara Municipal de Oeiras.

Choffat, P. 1895-98. Note sur les tufs de Condeixa et la découverte de l'hippopotame en Portugal. Comunic. *Direcção Trab. Geol. Port.* 3: 1-12.

Fontes, J. 1915-1916. Station paléolithique de Mealhada. *Comunicações dos Serviços Geológicos de Portugal* 11: 7-15.

Penalva, C. 1987. Les industries acheuléennes du Portugal. *L'Anthropologie*: 45-68.

Pinto, R.S. 1931. Sobre "*Elephas antiquus*" cfr. "*antiquus*" do Casal do Torcato (Alenquer). *Anais da Fac. Ciências do Porto* 17: 104-106.

Ribeiro, J.P.C. 1995-1997. A estação paleolítica da Mealhada.*O Arqueólogo Português* 13/15: 35-52.

Zbyszewski, G. 1943. Les eléphants quaternaires au Portugal. *Comunicações dos Serviços Geológicos de Portugal* 24: 71-89.

Zbyszewski, G. 1967. Le Mastodon du "Pliocene" de Santarém. *Comunicações dos Serviços Geológicos de Portugal* 52: 3-16

Zbyszewski, G. 1977a. Três ossos de vertebrados quaternários. *Comunicações dos Serviços Geológicos de Portugal* 61: 191-194.

Zbyszewski, G. 1977b. Nova Contribuição para o conhecimento da jazida quaternária da Mealhada. *Memórias e Notícias. Museu L.M.G.Univ. Coimbra* 84: 1-37.

Zilhão *et al.* 1991. A arqueologia da Gruta do Almonda (Torres Novas). Resultados das escavações de 1988-89. *Actas das IV Jornadas Arqueológicas (Lisboa 1990):* 161-171.

Taphonomy at Ambrona: new perspectives

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SUMMARY: This paper presents a taphonomic analysis of the faunal assemblages from the 1993-2000 excavations at Ambrona (Spain), directed by Manuel Santonja and Alfredo Pérez-González. Bone modifications considered in the light of sedimentary contexts indicate a significantly greater importance of natural processes in shaping the site structure than previously suggested.

1. INTRODUCTION

The new excavations have been directed mainly to a reanalysis of the stratigraphic sequence, of the sedimentary contexts and of processes of accumulation of faunal and lithic materials. Our objectives are to document, refute or support the opposing interpretations of the site proposed by F.C. Howell and L. Freeman (Howell *et al.* 1995; Freeman 1994) and by L.R. Binford (1987) concerning the hominid subsistence activities.

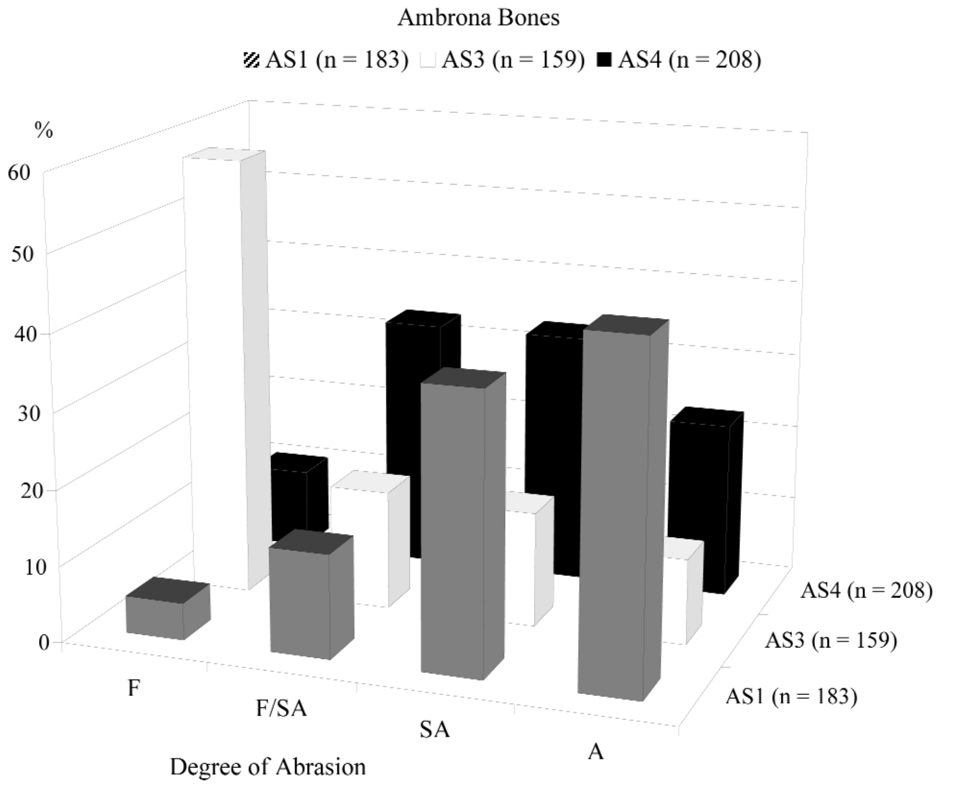
2. SEDIMENTARY CONTEXT AND TAPHONOMIC FEATURES

The faunal (mainly *Elephas antiquus, Bos, Equus, Dama, Cervus*) and lithic remains are found in varied sedimentary contexts: an alluvial fan, lacustrine muds, fluviatile sands and channel deposits. Faunal remains in the lacustrine muds (AS3) are often, but not always, in primary context. In this level remains of elephant and deer carcasses may be found in partial articulation or proximity and appear to represent natural occurrences without clear evidence of hominid intervention. In other contexts the faunal remains are occurrences of single anatomical elements either displaced by water or left isolated in situ.

Very limited evidence of anthropic action is provided by a few SEM verified cutmarks on isolated bones (a few elephant and bovid bones). In contrast, light and chaotic abrasion striations occur on many bones, due to mechanical friction by clasts during water transport processes or, less commonly, through expansion and contraction of clast-containig clays in the AS3 lacustrine muds. Single heavier grooves occurring occasionally on some elephant bones do not show features diagnostic of human action and may be due to trampling by live elephants. Trampling is actually suggested by distinctive depression fractures on elephant skulls and other large bones. Activities of live animals at the site is also suggested by the occurrence of more than 50 ivory points and flakes from juvenile tusks in these levels (Villa & d’Errico 2001). Breakage of tusk tips during activities, such as intra-specific fights or when elephants use their tusk for pushing and lifting heavy objects, digging for water, scraping soil for salt or stripping bark from trees, has been documented by Haynes (1991) in African game preserves. Thus the Ambrona ivory points cannot be considered evidence of the use of ivory by the hominids but are another indication of the importance of natural processes in the accumulation of materials at the site.

The extremely low frequency of convincing cutmarks (already noted by Shipman & Rose 1983) is partly a function of the very low proportions of observable bone surface. More than 80% of the bones (teeth and tusk fragments excluded) have surfaces that are either too altered or too abraded or too much covered with rootmarks to be observable. However the pattern of limited human intervention on bones is confirmed by the fact that fractures on fresh bones, of possible human origin, are also extremely rare. Most breakage patterns are either syn- or post-depositional, due to mechanical breakage in transport or to sediment pressure.

Bone surfaces show varying degrees of mechanical abrasion (Fig.1); occasionally bone fragments are so rolled that they have almost completely lost their original shape. The lowest incidence of mechanical abrasion occurs in level AS3 although even there about 40% of the bones show limited abrasion.



F = fresh; F/SA = fresh to slightly abraded; SA = slightly abraded; A = abraded to very abraded

Fig.1 - Degree of abrasion on bones from the lower levels at Ambrona. The sample does not include teeth and tusk fragments.

Comparable observations on water transport and degree of abrasion of stone artifacts are provided by Santonja & Pérez-González (2001).

3. DISCUSSION AND CONCLUSION

In conclusion, we suggest that data from the new excavations do not support the hunting hypothesis nor the scavenging alternative interpretation. Interpretations of particular association of stone tool types and faunal remains are not based on robust evidence and should be discarded. In fact, data on the sedimentary context, on the physical state of bone preservation, on biased and incomplete anatomical representation and on the scarcity of anthropic modifications clearly indicate that the stone and bone assemblages of Ambrona are a complex mix of natural and human components, and that natural processes of displacement, loss and postdepositional modification render the bone assemblage less informative of human activities than it has been suggested in the past. While the occurrence of human activities at the site is clearly indicated by few facts (including, of course, the occurrence of stone artifacts and of few cutmarks on bones) the extent and specific nature of the hominid-animal interaction, beyond a simple interpretation of perhaps occasional butchery, cannot be fully elucidated. Even if we choose to see the evidence of limited interaction as a form of scavenging, this reductionist interpretation is too weak to be extrapolated in terms of general human behavior patterns at other sites.

4. REFERENCES

Binford, L.R. 1987. Were there elephant hunters at Torralba? In M. Nitecki & D. Nitecki (eds.) *The Evolution of Human Hunting*: 47-105. New York: Plenum Press.

Freeman, L.G. 1994. Torralba and Ambrona. A Review of Discoveries. In R.S. Corruccini & R.L. Ciochon (eds.) *Integrative Paths to the Past*: 597-638. Englewood Cliffs, New Jersey: Prentice Hall.

Haynes, G. 1991. *Mammoths, Mastodonts, and Elephants*. Cambridge: Cambridge University Press.

Howell, F.C., Butzer, K.W., Freeman, L.G. & Klein, R.G. 1995. Observations on the Achelean occupation site of Ambrona (Soria Province, Spain). *Jahrb. Römisch-Germanischen Zentralmus*. Mainz 38: 33-82.

Howell, F. C., & Freeman, L. G. 1983. Ivory points from the earlier Acheulean of the Spanish Meseta. In *Homenaje al Prof. Martin Almagro Basch*: 41-61. Madrid: Ministerio de Cultura.

Klein, R. 1987. Reconstructing how early people exploited animals: problems and prospects. In M. Nitecki & D. Nitecki (eds.) *The Evolution of Human Hunting*: 11-43. New York: Plenum Press.

Santonja, M. & Pérez-González, A. 2001. Lithic artifacts from the lower levels of Ambrona (Spain). Taphonomic features. *This volume.*

Shipman, P. & Rose, J. 1983. Evidence of butchery and hominid activities at Torralba and Ambrona. *J. of Archaeol. Science* 10: 465-474.

Villa, P. & d'Errico, F. 2001. Ivory points in the Lower Paleolithic of Europe. *This volume.*

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Revisiting Torralba: old questions that generate more questions

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Torralba (Torralba del Moral, Spain) is an archaeological key in the reconstruction and understanding of the evolution and development of Palaeoanthropology. The excavations carried out for the marques de Cerralbo, and later by L. Freeman and F.C. Howell converted this archaeological site as the paradigm to relate the behavior of archaic hominids. Torralba typified and facilitated the existence of the hunting of big herbivores. In this sense, elephants were regular prey for the human groups of the Middle Pleistocene.

During the 80's this proposal was difficultly criticized by different authors. Among other arguments, these critics coincided in pointing out that the absence of specific contextual observations. These reservations prevented the evaluation and verification concerning the role developed by the human activity in the site formation. These seriously affected the role played by the human groups in the hunting of elephants

In this presentation we want to expose some elements of reflection obtained after the excavations carried out between 1994 and 1999. These observations suggest that Torralba is a deposit with a complex sedimentary and taphonomic history that limit the possibility to validate the classic explanation. These suggestions show that the archaeo-paleontological potential in Torralba is quite unknown; and at the same time, the determination of the human activity in the site formation and the possible interaction between elephants and human groups is equally difficult of evaluating.

Elephantoidea in the Indonesian region: new *Stegodon* findings from Flores

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SUMMARY: Recent discoveries of fossil *Stegodon* remains from the island Flores (Nusatenggara, Indonesia) are discussed. The findings confirm earlier discoveries from that island. An Early Pleistocene fossil island assemblage, dated at 0.9 Ma, contains the dwarfed *Stegodon sondaari* in association with *Varanus komodoensis* and giant tortoise remains. A Middle Pleistocene assemblage discovered at numerous localities and dated between 0.85 and 0.7 Ma, contains the intermediate to large-sized *Stegodon florensis*, the giant *Hooijeromys nusatenggara* and *V. komodoensis*. This fauna is associated with early humans as evidenced by the occurrence of stone tools at various localities. A juvenile skull of *S. florensis* shows that this species is closely related to the *S. trigonocephalus* group.

1. INTRODUCTION

Fossil Elephantoidea are important elements in each of the successive faunal units on Java. Their fossil remains are common in the vertebrate-bearing strata and they are good biostratigraphic indicators. Because of their great potential to colonize islands, fossil elephantoids are also frequently encountered on other islands in the region, which enhances their importance for biostratigraphic correlations of terrestrial deposits amongst the various islands.

Following the emergence of Java above sea-level from the Late Pliocene until ca. 1.5 Ma, mammalian dispersal to Java was limited. This is illustrated by impoverished faunal assemblages and the occurrence of various dwarfed elephantoids in this time interval, indicating isolated conditions. The earliest known well documented fauna from Java, the Satir fauna (2-1.5 Ma) contains a mastodon of Chinese origin, *Sinomastodon bumiajuensis*. There are no predatory mammals known from this fauna. Further uplift and volcanic activity in combination with episodes of low sea-level led to an increasing accessibility of the Java region between 1.5 and 0.8 Ma. *Stegodon* (*S. elephantoides* and *S. trigonocephalus*) appears to be the only Elephantoid genus present on Java around that time. The associated faunas (Ci Saat and Trinil Faunas, the latter including *Homo erectus*) are somewhat impoverished, suggesting filter dispersal. Corridor dispersal to Java occurred for the first time between 0.8-0.7 Ma. This time interval concurs with the arrival of the first modern, high-crowned *Elephas* (*E. hysudrindicus*) on Java. Only during the Late Pleistocene does *Elephas maximus* enter Java, associated with the first recorded rainforest fauna. *Stegodon* becomes extinct around that time. *E. maximus* becomes extinct on Java during the Holocene.

Evidence from Sulawesi and Flores indicates that those islands remained isolated from the mainland and from Java throughout the Quaternary. On both islands we find a succession of distinct endemic island faunas with dwarfed Elephantoids until the Middle Pleistocene. Around the early Middle Pleistocene these dwarfed Elephantoids are replaced by new immigrants of large- to intermediate size. Presumably, a period of prolonged low sea-level around 0.8 Ma led to an increased accessibility of these islands, though the associated faunas demonstrate a continued isolation. *Stegodon* remains are also known from the islands Timor, Sumba and various Philippine islands, but stratigraphic control is less accurate on these islands.

2. STEGODON FAUNAS FROM FLORES

On Flores a late Early Pleistocene island fauna with the very small *Stegodon sondaari* is replaced by a Middle Pleistocene island fauna with the medium to large-sized *Stegodon florensis*. *Stegodon sondaari* is the smallest elephantoid from the Indonesian region so far discovered, with an estimated bodyweight of around 300 kg (van den Bergh 1999). It occurs in a fossiliferous layer at the locality Tangi Talo, which has been dated by means of paleomagnetism and fission-track dating at 900 + 70 ka (Sondaar *et al.* 1994; Morwood *et al.* 1998, 1999). *S. sondaari* co-occurs with the still extant Komodo dragon, *Varanus komodoensis*, and a giant tortoise. The enamel microstructure of *S. sondaari* shows some primitive characteristics. On the other hand it possesses some derived characters in the form of increased hypsodonty and relatively large molar wear surface. This adaptation has evolved independently in various island stegodonts, whereas mainland stegodonts have remained very conservative in their brachyodont molars. Increased hypsodonty may be an adaptation to increased wear of the molars, because foraging should have been closer to the ground and the food more contaminated with sand and grid. Alternatively, the dwarfed island stegodonts may have been forced to include more tough grasses into their diet under the strong seasonal conditions on Flores.

In younger layers *S. sondaari* and tortoises have disappeared. These younger layers contain the intermediate to large-sized *Stegodon florensis*, known from a wide range of localities spanning a time interval of between 850 and 700 ka. Humans, as evidenced by artifacts, co-occur with *S. florensis* in some of the localities ranging in time between 840 – 700 ka (e.g. Boa Lesa, Mata Menge, Kobatuwa; Morwood *et al.* 1998, 1999). This suggests that *Homo erectus* was already able to cross limited sea-barriers at a very early stage.

3. NEW FINDINGS FROM FLORES

Recently, new fossil material of both *Stegodon* species has been collected from the Soa Basin, Ngada District, West Central Flores, during 4 successive fieldworks between 1996 and 1999. The material was recovered during a geological/archaeological study in the area carried out by a joint team composed of members from the Geological Research and Development Centre (GRDC) at Bandung, Indonesia, the University of New England, Armidale, Australia, and the National Institute of Archaeology (ARKENAS) at Jakarta, Indonesia.

Amongst the newly discovered *S. sondaari* material from Tangi Talo are some complete molar elements and fragments of postcranials not previously recorded. Postcranial elements of *S. sondaari* are pelvis and scapula. Also some relatively large tusk remains have been collected. The tusks appear to have been extensively used as shown by heavy abrasion on the ventro-medial surfaces, presumably for digging (waterholes, edible roots?). The material also contains a mandible with both the left and right dentition preserved (TT4255). At both sides a small completely worn remnant of the dP_4's in front is still unshed, followed by the half worn M_1's. Of the left side the ascending ramus is preserved with an anterior fragment of the M_2 under formation still in the alveole. The dental wear pattern allows to attribute the mandible to dental wear stage dP4/M1-C, age class 1 (van den Bergh 1999). The individual was slightly younger than that of the holotype mandible, in accordance with its slightly smaller size (Fig. 1).

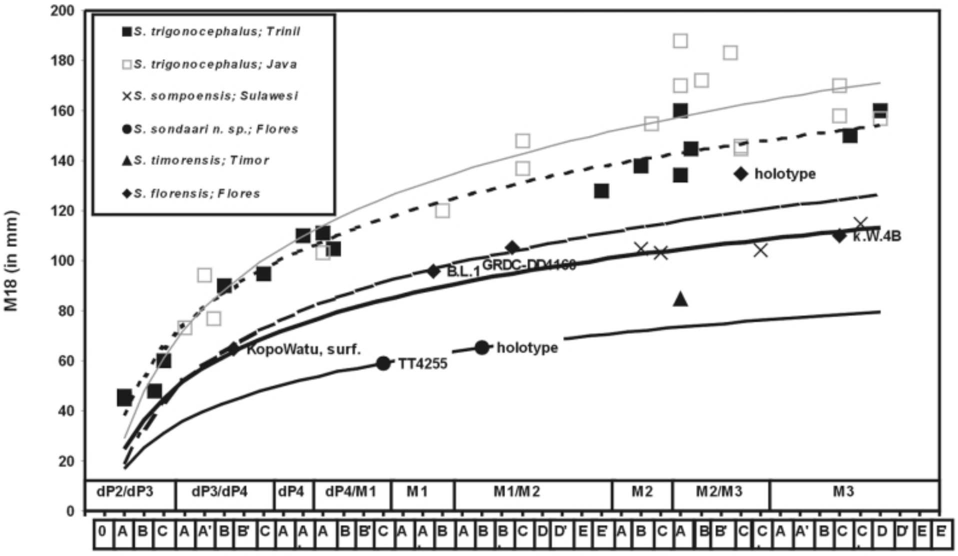

Fig.1 - Maximum transverse diameter of the mandibular horizontal ramus as a function of dental wear age class for various *Stegodon* species from Indonesia (for more details on the methods see van den Bergh *et al*. 1999).

The prize specimen from the 1996-1999 collection is certainly an almost complete juvenile skull of *S. florensis* from the locality Kopo Watu. There are also several mandibles with dentition amongst the newly collected material. The skull, with the catalogue number K.W.1, is the first skull of *S. florensis* on the record. The dentition is preserved on both sides and consists of both worn dP^4's and the unworn M^1's. The state of wear allows to ascribe the present individual to Dental Wear Age Class dP^4-A', or age group 1(juvenile; see van den Bergh 1999). The individual was slightly younger than the type skull of *S. trigonocephalus*, in which the first ridges of the M1's are worn. The similar age class allows a good comparison between the two species. It follows that the size of specimen K.W.1 is a little smaller than the slightly older individual of the *S. trigonocephalus* type skull. The skull is smaller than the adult skull of the dwarfed *S. sompoensis* from the Walanae Fauna in South Sulawesi. The morphology of the present skull shows great resemblance with that of *S. trigonocephalus*. The wide fronto-parietal region with a wide nasal opening, and the pear-shaped depression between the cresta orbitotemporalis and the cresta orbitalis ventralis indicate a close relationship between the two species. Major differences are the more advanced molars. The molars are more hypsodont (though this could not be verified in the present skull), and homologue molars may have one ridge more than in the subspecies *S. trigonocephalus trigonocephalus* from the Javanese localities Trinil and Kedung Brubus (Tab. 1). Note that in *S. trigonocephalus ngandongensis* from the Late Pleistocene Javanese localities Ngandong, Watualang and Grenjengan (van den Bergh 1999) the ridge crest formula is even more advanced than in the Middle Pleistocene *S. florensis*. Furthermore, skull K.W.1 exhibits a retracted nuchal crest with a weak tendency of the parietals to become inflated. The latter feature is even more developed in *S. orientalis*, in which the adults have a pair of prominent domes on the vertex of the skull (Saegusa 1993). However, *S. orientalis* differs from the present skull in having a total loss of the nuchal crest and the development of a shallow groove on the forehead. The slightly inflated parietals in specimen K.W.1 more likely represents a juvenile character. *S. florensis* appears closely related to the *S. trigonocephalus* group.

Tab.1 - Ridge crest formulas of various *Stegodon* (sub)species from Indonesia.

		dP2	dP3	dP4	M1	M2	M3
S. sondaari	Upper	-	6-7	6	6-7	-	8
	Lower	-	6	-	8	8	8
S. florensis	Upper	-	-	6	7	-	12
	Lower	-	-	7-7+	8-9	10	14
S. trigonocephalus trigonocephalus	Upper	-	6	7-8	7	9	11
	Lower	-	6	8	8-9	10	13
S. trigonocephalus ngandongensis	Upper	-	-	-	-	-	-
	Lower	-	7	9	9+	-	-

Inclusion of the newly collected dental material in the death assemblage of *S. sondaari* from Tangi Talo (Fig. 2) confirms the earlier hypothesis that this assemblage reflects the structure of a living population (Haynes 1991; van den Bergh 1999). It seems that non-selective mortality affected an entire population, including prime-adults. In combination with the nature of the layer in which the fossils are found (a tuffaceous layer with abundant pumice), a catastrophic volcanic eruption is the most likely cause for the death of the animals. The time-averaged composite death assemblage of *S. florensis* is dominated by senior and very old individuals, together comprising 42% of the minimum number of individuals, which is more than the total percentage of the juvenile age group (35%). The assemblage may be biased because the material includes specimens described by Hooijer (1967, 1972), who may have preferentially described the easily recognizable tapering M3's. An explanation for the relative high percentages of old individuals could be that living conditions on Flores were quite optimal and that mortality amongst the juveniles and prime-aged individuals was exceptionally low. But other explanations, such as selective removal of juveniles from the assemblage by predating komodo dragons can also be put forward. How the proven presence of humans fits in is not clear at the moment. So far no evidence for butchering sites has been found in the Soa Basin.

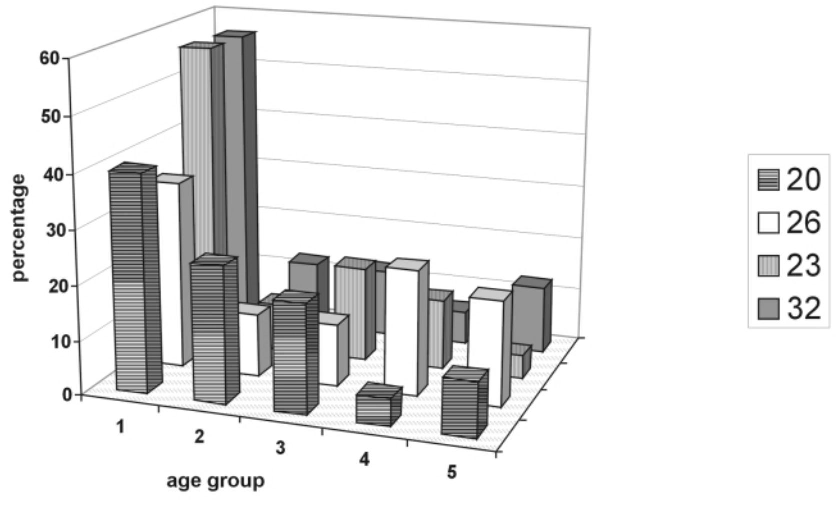

Fig.2 - Age profiles of fossil Elephantoid assemblages from various localities in Indonesia. Legend indicates the minimum number of individuals on which each profile is based. From front to back: *S.sondaari* from the locality Tangi Talo; *S. florensis* from various localities in the Soa Basin, Flores; *"Elephas" celebensis* from

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5. REFERENCES

Haynes, G. 1991. *Mammoths, mastodonts and elephants, biology, behaviour, and the fossil record*. Cambridge: Cambridge University Press.

Hooijer, D.A. 1967. Indo-Australian insular elephants. *Genetica* 38: 143-162.

Hooijer, D.A. 1972. *Stegodon trigonocephalus florensis* Hooijer and *Stegodon timorensis* Sartono from the Pleistocene of Flores and Timor. I & II. *Proc. Kon. Nederl. Akad. Wetensch.*, Series B, 75: 12-33.

Morwood, M.J., Aziz, F., O'Sullivan, P., Nasruddin, Hobbs, D.R., Raza, A. 1999. Archaeological and palaeontological research in central Flores, east Indonesia: results of fieldwork 1997-98. *Antiquity* 73: 273-286.

Morwood, M.J., O'Sullivan, P., Aziz, F. and Raza, A. 1998. Fission track age of stone tools and fossils on the east Indonesian island of Flores. *Nature* 392: 173-6.

Morwood, M.J., Soejono, R.P., Sutikna, T. 2001. The archaeology of Liang Bua, west Flores, Indonesia: preliminary report on the 2001 excavations. *Internal report, Univ. of New England, Australia*.

Saegusa, H. 1993. A note on Cranial Materials of *Stegodon orientalis* Owen, 1870 (Stegodontidae, Proboscidea) from Yanjingou, Sichuan, China. *Humans and Nature* 2: 95-103.(In Japanese with English abstract).

Sondaar, P.Y., Van den Bergh, G.D., Mubroto, B., Aziz, F., De Vos, J. & Batu, U.L. 1994. Middle Pleistocene faunal turn-over and colonisation of Flores (Indonesia) by *Homo erectus*. *Comptes Rendues de l'Academie des Sciences* 319: 1255-1262.

Van den Bergh, G.D. 1997. The Late Neogene elephantoid-bearing faunas of Indonesia and their palaeozoogeographic implications. A study of the terrestrial faunal succession of Sulawesi, Flores, and Java, including evidence for early hominid dispersal east of Wallace's Line. *Scripta Geologica* 117: 1-419.

6. POSTSCRIPTUM

During a recent excavation in the cave Liang Bua, for the first time *Stegodon* fossils have been discovered in a cave setting on Flores. Previous excavations in Liang Bua had yielded Neolithic and Metal age graves in the uppermost 2.2 m of the cave floor, underlain by Mesolithic and then Palaeolithic stone artefacts to a minimum depth of 4.25 m. The recent excavation reached a maximum depth of 6.8 m and yielded the remains of an archaic hominid population, stone artefacts, *Stegodon,* giant tortoise, pig, deer and Komodo dragon in the basal levels. This deposit is overlain by 3 lenses of tuffaceous silt, providing a potential source for dating (Morwood *et al* 2001). The remains of at least 3 juvenile *Stegodon* individuals seem to be involved, but a detailed study of the material has still to be done.

The World of Elephants - International Congress, Rome 2001

Molecular phylogeny of living elephants and discussion on infraspecific systematics of *Loxodonta africana* and *Elephas maximus*

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SUMMARY: This poster communication displays the results of the phylogenetic analyses of new sequencing data from three mitochondrial markers (Cytochrome b, 12S ribosomal DNA and control region genes) among African (both bush and forest forms) and Asian elephants (of every subspecies). Maximum Parsimony (MP) procedure with equal and differential weighting and Maximum Likelihood (ML) analyses were applied to these data sets. To estimate the robustness of MP topologies, Bremer supports and Bootstrap proportions (excluding uninformative sites) were both calculated. Though evolving at different rates, the three markers studied are homogeneous and; depict a shared pattern of differentiation within every species of elephants, the robustness of which increases when data are combined. Within Asian elephants, this pattern accords neither with the geographic distribution nor with the systematic frame. On the contrary, a split between *Loxodonta africana africana* (bush form) and *Loxodonta africana cyclotis* (forest form) is recognized although none of these two subspecies is found to be monophyletic.

1. SAMPLING EFFORT

In order to examine the more comprehensive sample of elephants as possible, we used different types of samples collected in several zoos, circuses and reserves. We also took advantage of a collaboration with the Aane Mane Foundation (India). With respect to the forest African elephants, the greatest part of our sample is based on collection specimens from the Musée Royal d'Afrique Centrale (Tervuren, Belgium), the Muséum National d'Histoire Naturelle (Paris, France), and the Musée d'Histoire Naturelle de Fribourg (Switzerland): actually, 12 *Loxodonta africana cyclotis*, 18 *Loxodonta africana africana* and *35 Elephas maximus* were compared.

2. POLYMORPHISM IN ASIAN ELEPHANT

In Asia, we found partitioning between two sets of mitochondrial haplotypes. The divergence between these two sets is clear and could be very old: the divergence dates of clades within species can be estimated by the comparison of averaged pairwise-distances calculated between every member of clades of interest. The calibration of this molecular clock is based on the hypothetical date of divergence between Asian and African lineages fixed to 5 to 7 Ma. However, considering that one of the main clusters of Asian elephants is highly divergent with regard to the other, such calculations are certainly biased: critical demographic events in the history of these two lineages could tilt back their divergence date.

Anyway, this partitioning is thoroughly inconsistent with the geographic origin of the specimens sampled. The level of polymorphism is high in each continental country, particularly India and Burma which display the largest samples. The few specimens from Sri-Lanka and Sumatra indicate that the classical systematics of Asian elephant, based on geography, is artificial: the division of insular and continental populations should be regarded as a recent (Pleistocene?) event.

3. HOW MANY SPECIES OF AFRICAN ELEPHANTS?

For the past century, the systematic status of the forest African elephant (*Loxodonta africana cyclotis* Matschie 1900) has been questioned: though conventionally regarded as a subspecies, it was elevated to the specific rank in several morphological studies (Frade 1955; Groves & Grubb 2000; Grubb *et al.* 2000).

Barriel *et al.* (1999) sequenced the first cytochrome b gene of a forest African elephant. They thus showed this lineage seemed to be highly divergent from the bush African elephant (*Loxodonta a. africana*). Further analyses of greater samples of the these two forms provide complex information (Debruyne 2000; Debruyne *et al.* in prep.; Van Holt 1999).

Firstly, a clear division exists between two sets of mitochondrial haplotypes in Africa. This division keeps most of *L. a. cyclotis* (including “pygmy” elephants) and *L. a. africana* separated. Then, the difference established on morphological grounds is retrieved on molecular grounds.

Secondly, several individuals of the *L. a. africana* form (3 among 18) display three mitochondrial haplotypes which are characteristic of *cyclotis* form. None of these two taxa is therefore monophyletic and *cyclotis* as well as *L. a. africana* should not be considered as valid phylogenetic species. This introgression of forest mitochondrial genome in bush populations is regarded as persistence of effective gene flow between the two forms. Indeed, deep coalescence is very unlikely due to high number of events needed to fit the observed distribution of haplotypes.

4. REFERENCES

Barriel, V., Thuet, E. & Tassy, P. 1999. Molecular phylogeny of Elephantidae. Extreme divergence of the extant forest African elephant. *C. R. Acad. Sci. Paris* 322: 447-454.

Debruyne, R. 2000. *Phylogénie moléculaire des éléphants (Mammalia, Proboscidea) et position du mammouth laineux*. Mémoire de DEA. Paris. Unpublished. 29p.

Frade, F. 1955. Ordre des Proboscidiens (Proboscidea, Illiger1811). In P.P. Grassé (ed.) *Traité de Zoologie*: 715-875. Paris: Masson.

Groves, C.P. & Grubb, P. 2000. Do *Loxodonta cyclotis* and *Loxodonta africana* interbreed? *Elephant* 2(4): 4-7.

Grubb, P., Groves, C.P., Dudley, J.P. & Shoshani, J. 2000. Living African elephants belong to two species: *Loxodonta africana* (Blumenbach, 1797) and *Loxodonta cyclotis* (Matschie, 1900). *Elephant* 2(4): 1-4.

Van Holt, A. 1999. *Le statut systématique de l’éléphant africain de forêt ; apport des données de cytochrome b.* Mémoire de DEA. Paris.

The World of Elephants - International Congress, Rome 2001

New mitochondrial data demonstrating a close relationship between *Mammuthus primigenius* (Blumenbach, 1799) and *Loxodonta africana* (Blumenbach, 1797)

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SUMMARY: The question of the phylogenetical relationships between recent Elephantidae has been raised on morphological but also molecular grounds. Mitochondrial data (cytochrome b gene particularly) either support or question the classical scheme which associates *Mammuthus primigenius* with the Indian elephant, *Elephas maximus* Linné 1758. Recent studies depict a closer relationship between mammoth and African elephant, *Loxodonta africana*. We report the partial sequencing of two mitochondrial markers from a 49,000 years old Siberian mammoth. The comparison of its sequence with 10 other mammoths and with African (both bush and forest forms) and Asian elephants gives weight to this hypothesis. However, a previous study of the same specimen (Yang *et al.* 1996) produced a highly divergent sequence that clusters with Indian elephants. The accuracy of the two alternative sequences is evaluated and leads us to the conclusion that the woolly mammoths form the monophyletic sister-group of African elephants on molecular grounds.

1. Extraction and Sequencing of DNA from the Lyakhov Mammoth

We performed DNA extraction on the only complete specimen of Siberian mammoth conserved out of Russian territory. This specimen, a male adult that lived on Lyakhov main island (North-East Siberia) more than 49,000 years ago, was offered to the Muséum National d'Histoire Naturelle in 1912. Its skeleton is visible at the Galerie de Paléontologie (MNHN, Paris, France). Samples of dry skin and a sesamoide bone of the right foot were collected and submitted to a phenol/chloroform extraction protocol (Hassanin *et al.* 1998). No positive extraction was carried out for skin samples although a previous study, led by Yang et al. (1996), had used the same tissue from this specimen as a valid source of DNA prior to direct sequencing of partial cytochrome b gene.

On the other hand, positive extracts were obtained with the bone. We determined the maximal size of amplifiable DNA; thanks to a complete range of PCR length from 100 to 250 bp, we yielded usable products up to 180 bp. These results are consistent with other studies on similar material concerning fragmentation of DNA through time. They are also far less enthusiastic than those of Yang *et al.* (1996) who retrieved fragments up to 400 bp using extracts of DNA from skin.

The repeatable positive PCR we obtained were sequenced manually with 15 primers determining overlapping domains. 566 bp of cytochrome b and 128 bp of 12S ribosomal DNA were finally considered.

2. Comparison between the two sequences of Cytochrome b from Lyakhov Mammoth

Yang *et al.* (1996) sequenced a 228 bp domain of cytochrome b that our sequence (Debruyne *et al.,* in prep.) completely overlaps. Along this domain, these two sequences differ on 9 positions (Fig. 1). For each of these positions, our sequence displays the typical charac-

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                                 1111111111122222222222333
                                 1344556678801122246678011
                                 7245062513976935864705025

M.p. Noro                        AAGTTCTTTTTCTCTCTATTCCATG
M.p. Ozawa                       .........................
M.p. Thomas (a)                  .........................
M.p. Thomas (b)                  .........................
M.p. Thomas (c)                  .....T...................
M.p. Thomas (d)                  .GA........T....C........
M.p. Derenko                     .........................
M.p. Greenwood                   .G.......................
M.p. this study (Lyakhov)        .........................
M.p. Yang (b)   (Lyakhov)        G.A.C..C...T.G..CG.N....A
M.p. Yang (a)                    G.A.C..C...TCG..C.CC.....
E.m. indicus (India)             G.A.C..C....C...CG.CT...A
L.a. africana (S.-Afr)           ..A.C...C..T.G..C.C......
L.a. cyclotis (S.-Leone)         ..ACC.CCC....A.TC.....G.A
M. americanum Yang               ..A.C...CCC...ATC.CC.T.CA
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Fig.1 - Display of variable positions between the two sequences of Lyakhov mammoth (in boldface). *M.p. : Mammuthus primigenius; E.m.: Elephas maximus; L.a.: Loxodonta africana; M. americanum: Mammut americanum.*

ter found among sequences of mammoths. On the other hand, the sequence of Yang *et al.* (1996) shows the same character states as Asian elephants for 7 of these positions (the 2 other ones being shared with African elephants only).

When unweighted-parsimony analysis is applied to this fragment, these two sequences are kept separated: our sequence clusters with 8 sequences of other mammoths from 5 different studies (Derenko *et al.* 1997; Greenwood *et al.* 1999, Noro *et al.* 1998; Ozawa *et al.* 1997; Thomas *et al.* 2000) while the other sequence of Lyakhov mammoth branches deeply within Asian elephant sequences (Fig. 2).

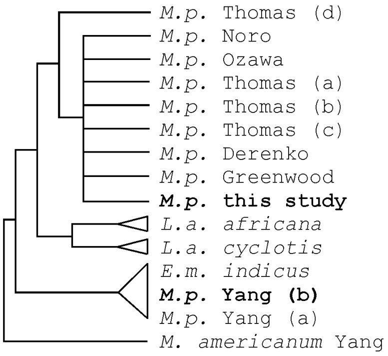

Fig.2 - Summary of the analyses of cytochrome b gene (acronyms see Fig. 1).

Considering the material studied, the conditions of DNA extraction (our inability to reproduce extracts using skin samples is notable), the differential length of fragments amplified by Yang *et al.* (1996) and this study, and the discrepancy between the two sequences of cytochrome b for Lyakhov mammoth, we consider that Yang *et al.'s* sequence is the result of a contamination by non-identified exogene DNA.

3. AFFINITIES OF THE MAMMOTH CLADE

With the exception of Yang *et al.'s* sequences, all the sequences of woolly mammoths form a clade (Fig. 2). The 8 longest sequences (including ours) cluster and are highly supported by both statistical indices and Bremer score (more details in Debruyne *et al.* in prep.).

Nevertheless, the sister-group association of this mammoth clade with African elephants is not so well supported. To determine whether this monophyly is robust and reliable, we performed several treatments on the matrix:

(1) application of a general-reversible model of likelihood analysis with heterogeneity in the variation of the positions.

(2) Hassanin *et al.* (1998) weighting was used to estimate the impact of mutational saturation on topology.

(3) decompositions of the matrix following the ordination of values for retention index of the positions demonstrated the reliability of the basal node of Elephantids.

(4) application of the PRN method (Lecointre *et al.* 1994) was used to estimate whether the molecular data available for woolly mammoths are sufficient to establish the close relationships of this species towards extant elephants.

None of these treatments was able to dismiss the association of *Mammuthus* and *Loxodonta* in a clade.

3. REFERENCES

Debruyne, R., Barriel, V. & Tassy, P. in prep. *Mitochondrial cytochrome b of the Lyakhov mammoth (Proboscidea, Mammalia): new data and phylogenetic analyses of the Elephantidae*.

Derenko, M., Malyarchuk, B. & Shields, C.F.G. 1997. Mitochondrial cytochrome b sequence from a 33,000 year-old woolly mammoth (*Mammuthus primigenius*). *Ancient Biomolecules* 1(2): 109-117.

Hassanin, A., Lecointre, G. & Tillier, S. 1998. The “evolutionary signal” of homoplasy in protein-coding gene sequences and its consequences for a priori weighting in phylogeny. *C. R. Acad. Sci. Paris* 321: 611-620.

Lecointre, G., Philippe, H., Van Le, H.L. & Le Guyader, H. 1994. How many nucleotides are required to resolve a phylogenetic problem? The use of a new statistical method applicable to available sequences. *Mol. Phyl. Evol.* 3(4): 292-309.

Noro, M., Masuda, R., Dubrovo, I.A., Yoshida, M.C. & Kato, M. 1998. Molecular phylogenetic inference of the woolly mammoth *Mammuthus primigenius*, based on complete sequences of mitochondrial cytochrome b and 12S ribosomal gene. *J. Mol. Evol.* 46: 314-326.

Ozawa, T., Hayashi, S. & Mikhelson, V.M. 1997. Phylogenetic position of mammoth and Steller's sea cow within Tethytheria demonstrated by mitochondrial DNA sequences. *J. Mol. Evol.* 44: 406-413.

Thomas, M.G., Hagelberg, E., Jones, H.B., Yang, Z. & Lister, A.M. 2000. Molecular and morphological evidence on the phylogeny of the Elephantidae. *Proc. R. Soc. Lond.* 267: 2493-2500.

Yang, H., Golenberg, E.M. & Shoshani, J. 1996. Phylogenetic resolution within the Elephantidae using fossil DNA sequence from the American mastodon (*Mammut americanum*) as an outgroup. *Proc. Nat. Acad. Sci. USA* 93: 1190-1194.

The *Stegotetrabelodon* remains from Cessaniti (Calabria, Southern Italy) and their bearing on Late Miocene biogeography of the genus

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SUMMARY: Remains of *Stegotetrabelodon* from Southern Italy are reported: and are the first specimen of this genus ever found in Eurasia. The material consists of a mandible and a lower tusk fragment collected at Cava Brunia, Cessaniti (Vibo Valentia, Calabria), in late Tortonian *Clypeaster*-bearing coastal sands. The morphology of the mandible and teeth conforms to the Libyan species *S. syrticus* although it retains some primitive traits. The occurrence of this elephantid and other mammal species with African "affinity" at Cessaniti, suggests the belonging of Calabria-Sicily area to a northern extension of the African continent. The Cessaniti elephantid brings new informations on the morphological variability of *Stegotetrabelodon* and provides clues of an early diffusion of the genus since the Tortonian.

1. INTRODUCTION

New remains of *Stegotetrabelodon* from Southern Italy are the first fossils ever found outside of Africa-Arabia of this taxon (Ferretti *et al.*, in press). The material consists of a mandible and a lower tusk fragment collected at Cava Brunia, Cessaniti (Vibo Valentia, Calabria), in late Tortonian - pre Messinian *Clypeaster*-bearing coastal sands (Nicotera 1959; Ogniben 1973; Papazzoni & Sirotti 1999). The occurrence of this elephantid and other mammal species with African "affinity" at Cessaniti, suggests that during Tortonian, the Calabro-Peloritan massif was part of the Northern Africa shelf (Rook *et al.* 2000; Torre *et al.* 2000).

2. DESCRIPTION

The Cessaniti mandible represents a fully mature individual (Figs. 1-3). The specimen differs from other tetralophodont longirostrine elephantoidea (e.g. *Tetralophodon* and "*Mastodon*" *grandicisivus*) for the reduction of the central conules, for the slight separation of the pre and post-trite complex and for the large size of the mesoconelets, resulting in the formation of a primitive plate-like (i.e. elephantine) pattern.

The inner structure of the tusk does not show the tubular pattern typical of "*M.*" *grandincisivus* (Tobien 1978; Tassy 1985) and it also differs in its elliptical shape from the sub-circular section of *Tetralophodon longirostris*.

The symphysis, although incomplete, clearly shows the marked downward bending typical of *Stegotetrabelodon*, that contrast with the condition known from *Tetralophodon* and *M. grandincisivus*.

The characters displayed by the mandible (long and down turned symphysis), the molars (in particular the number and structure of the plates) and the lower incisor (oval cross section, lamellar inner structure) are diagnostic of *Stegotetrabelodon*.

Stegotetrabelodon is currently represented by two African species, namely *Stegotetrabelodon syrticus* Petrocchi (1941) (=*Stegotetrabelodon lybicus* Petrocchi 1943, and *Stegolophodon sahabianus* Petrocchi 1943) and *Stegotetrabelodon orbus* (Maglio 1970).

The Cessaniti specimen favours a close comparison with *S. syrticus*. The retention of some

Fig.1 - *Stegotetrabelodon* cf. *syrticus* from Cessaniti. Mandible (MFE 935) in occlusal aspect. Scale bar represents 10 cm.

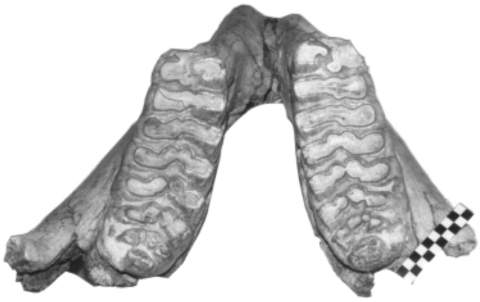

Fig.2 - *Stegotetrabelodon* cf. *syrticus* from Cessaniti. Mandible (MFE 935) in left lateral aspect. Scale bar represents 10 cm.

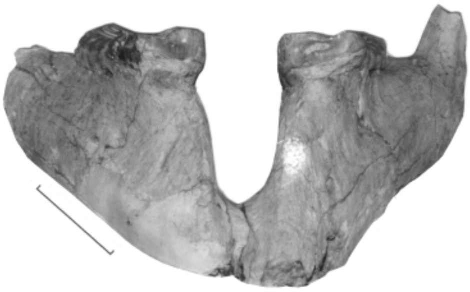

Fig.3 - *Stegotetrabelodon* cf. *syrticus* from Cessaniti. Mandible (MFE 935) in frontal aspect. Scale bar represents 10 cm.

plesiomorphic features, such as, the orientation of the mandibular rami, a lesser downward deflection of symphysis, and some dental traits, suggests caution in the attribution to this species, even if these differences could represent intraspecific variability.

3. CONCLUSIVE REMARKS

Stegotetrabelodon syrticus was originally known only at Sahabi, a late Miocene locality from northern Libya, and it has been recently recorded also at Abu Dabi (Tassy 1999). *Stegotetrabelodon orbus* was defined on material from Lothagam 1 (Kenya; Maglio 1970, 1973) and has been recorded also in other East African localities ranging between late Miocene and basal Pliocene: Lower Adu Asa (Middle Awash, Etiopia), Mpesida (Baringo basin, Kenya) (Kalb & Mebrate 1993) and Lubeho (Ibole Mbr, Manonga valley, Tanzania) (Sanders 1997).

The age of the Cessaniti *Stegotetrabelodon* (Tortonian, Late Miocene; Fig. 4) is comparable to that proposed by Tassy (1999) for the *Stegotetrabelodon syrticus* from Abu Dhabi

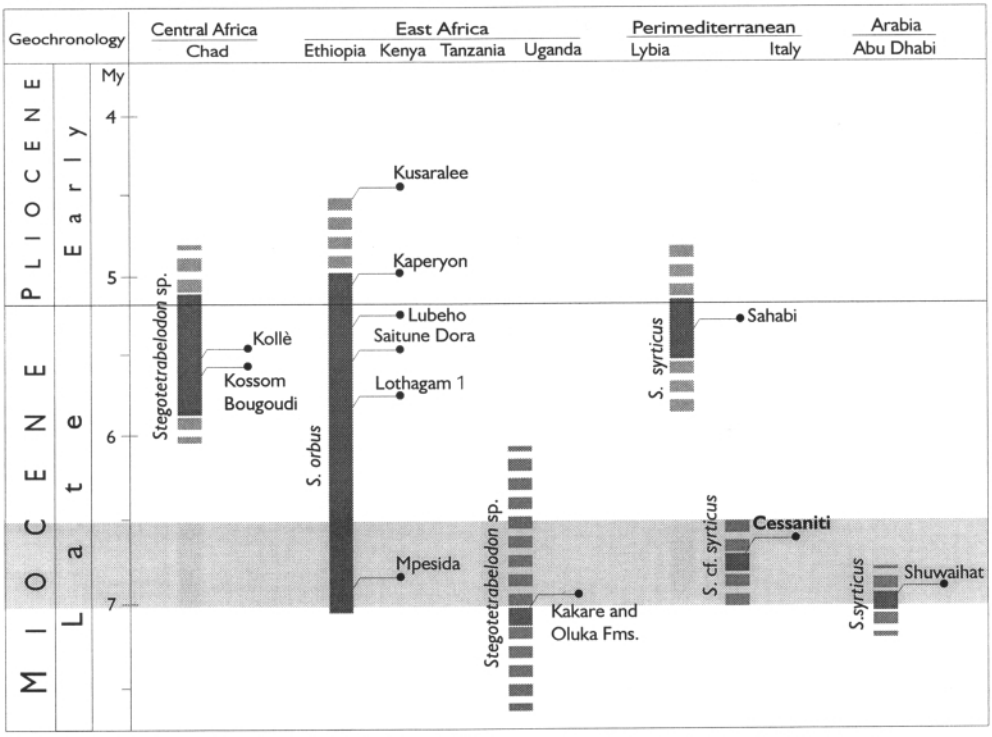

Fig. 4 - Temporal and geographical distribution of *Stegotetrabelodon* (data from Maglio 1973; Geraard 1989; Kalb and Mebrate 1993; Tassy 1995; 1999; Mackaye 2000).

and matches that of *Stegotetrabelodon orbus* from Mpesida (Kenya; Bishop 1976; Bishop *et al.* 1969).

Stegotetrabelodon sp. from the Kakara and Oluka Formations in Uganda (Tassy, 1995) may be slightly older, but the time range given for this levels does not exclude the possibility that the Ugandan sites are actually contemporaneous with the other cited localities (Fig. 4). There is evidence thus that *Stegotetrabelodon* was already widespread in the Tortonian, around 7 Ma, from Uganda to northern Africa and eastward to the eastern shore of the Arabian platform.

4. REFERENCES

Bishop, W.W. 1976. Pliocene problems relating to human evolution. In G.L.I. Issac & E. R. McCown (eds) *Human Origins*: 139-153. Benjamin, Menlo Park.

Bishop, W.W., Miller, J.A. & Fitch, F.J.. 1969. New potassium-argon determinations relevant to the Miocene mammal sequence in East Africa. *Amer. J. Sci.* 267: 669-699.

Ferretti, M., Torre, D. & Rook, L. in press, *Stegotetrabelodon* cf. *syrticus* (Proboscidea, Elephantidae) from the Upper Miocene of Cessaniti (Calabria, southern Italy) and its bearing on Late Miocene Paleogeography of central Mediterranean. *J. Vert. Paleont.*

Geraads, D. 1989. Vertebres fossiles du Miocène supérior du Djebel Krechem El Artsouma (Tunisie centrale). *Géobios* 22: 777-801.

Kalb, E.J. & Mebrate, A. 1993. Fossil elephantoids from the hominid-bearing Awash Group, Middle Awash Valley, Afar Depression, Ethiopia. *Trans. Am. Phil. Soc.* 83: 1-114.

Mackaye, H.T. 2000. Les proboscidiens du Mio-Plio-Pleistocene du Tchad: biodiversite, biochronologie, paleoenironnement. *Abstracts 5th European Workshop on Vertebrate Paleontology* 1: 49, Karlsruhe.

Maglio, V.J. 1970. Four new species of Elephantidae from the Plio-Pleistocene of northwestern Kenya. *Breviora* 342:1-43.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.* 63 (3): 1-144.

Nicotera, P. 1959. Rilevamento geologico del versante settentrionale del monte Poro (Calabria). *Memorie e Note Ist. Geol. Appl. Napoli* 7: 1-92.

Ogniben, L. 1973. Schema geologico della Calabria in base ai dati odierni. *Geologica Romana* 12: 243-585.

Papazzoni, C.A. & Sirotti, A. 1999. *Heterostegina papyracea* Seguenza, 1880 from the upper Miocene of Cessaniti (Vibo Valentia, Calabria, southern Italy). *Boll. Soc. Paleont. It.* 38:15-21.

Petrocchi, C. 1941. Il giacimento fossilifero di Sahabi. *Boll. Soc. Geol. It.* 60: 107-114.

Petrocchi, C. 1943. Il giacimento fossilifero di Sahabi. *Coll. Sci. Document. Min. Afr. Ital.* 12: 1-162.

Rook, L., Mazza, P., Rustioni, M. & Torre, D. 2000. Lands and endemic mammals in the Late Miocene of Italy: paleogeographic outlines of Tyrrhenian and Adriatic areas between 11-9 and 7-4ma. *In ESF Scientific Programme on "Environments and Ecosystem Dynamics of the Eurasian Neogene" (EEDEN). Workshop on "State-of-the-art", University of Lyon, 16-18 November 2000. Abstract book.*

Sanders, W.J. 1997. Fossil Proboscidea from the Wembere-Manonga Formation, Manonga Valley, Tanzania. In T. Harrison (ed.) *Neogene Paleontology of the Manonga valley, Tanzania*: 265-310. Plenum Press.

Tassy, P. 1985. *La place des mastodontes miocènes de l'ancien Monde dans la Phylogènie des Proboscidea (Mammalia): hypothèses et conjectures.* Ph.D. dissertation, University P. and M. Curie. Paris. 862 pp.

Tassy, P. 1995. Les Proboscidiens (Mammalia) fossiles du Rift Occidental, Ouganda. In B. Senut & M. Pickford (eds) *Geology and paleobiology of the Albertine rift valley, Uganda-Zaire. Vol. 2, Paleobiology*: 215-255. Orléans: Centre Int. pour la Formation et les Echanges Géologiques.

Tassy, P. 1999. Miocene elephantids (Mammalia) from the Emirate of Abu Dhabi, United Arab Emirates: Palaeobiogeographic Implications. In P. J. Whybrow & A. Hill (eds.) *Fossil Vertebrates of Arabia*: 209-233. Yale university Press.

Tobien, H., 1978, On the evolution of Mastodonts (Proboscidea, Mammmalia). Part 2: The bunodont tretralophodont Groups. *Geol. Jahrbuch Hessen* 196:159-208.

Torre D., Abbazzi, L. Delfino, M., Fanfani, F., Ferretti, M.P., Ficcarelli, G., Mazza, P., Rustioni, M. & Rook L. 2000. Mammal palaeobioprovinces in the Italian Miocene. *XIth RCMNS Congress, Abstracts* 1: 43. Fez.

Morphologic analysis of the hippocampal formation in *Elephas maximus* and *Loxodonta africana* with comparison to that of human

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SUMMARY: The hippocampal formation (HC) of mammals is a component of the limbic system of the brain hidden deep within the cerebral hemispheres in close association with the medial temporal lobe. Although the HC has been well studied in primates, little anatomic information is available concerning the detailed anatomy of the HC in the elephant, a large mammal proverbial for its powers of memory. We present an anatomic analysis of the HC in an Asian elephant *Elephas maximus* (female, age 34 years) and in an African elephant *Loxodonta africana* (female, age 46 years). Our investigations include macroscopic descriptions of the HC and microscopic analysis of histologic preparations.

1. INTRODUCTION

The hippocampal formation (HC) of mammals is a component of the limbic system of the brain hidden deep within the cerebral hemispheres in close association with the medial temporal lobe. The HC is believed to play an important role in learning and memory and may as well, through its limbic connections, play a role in the control of emotional behaviors and neuroendocrine functions. In higher mammals manifesting complex behaviors, such as cetaceans, proboscideans, and primates, the HC is small relative to the large size of the cerebrum. Although the HC has been well studied in primates, relatively little detailed anatomic information is available concerning the anatomy of the HC in the elephant (Dexler 1907; Haug 1970; Janssen & Stephan 1956; Koikegami *et al.* 1941). Our objectives have been to study the anatomical homologies between the HC of the elephant, a large mammal proverbial for its powers of memory, and of the human and to infer possible functions based on knowledge from the human HC. The pathologic involvement of the human HC in neurodegenerative diseases associated with old age such as Alzheimer's disease raises the question of the occurrence of similar changes in elderly elephants.

2. MATERIALS AND METHODS

We present an anatomic analysis of the HC in formaldehyde-fixed brain specimens obtained from an Asian elephant *Elephas maximus* (female, age 34 years) and an African elephant *Loxodonta africana* (female, age 46 years).

Our investigations include macroscopic descriptions of the HC and microscopic analysis of histologic preparations using paraffin-embedded material sectioned at 10u and stained with Luxol fast blue/cresyl violet, hematoxylin and eosin, and Bielschowsky methods and 30u sections stained with cresyl violet alone.

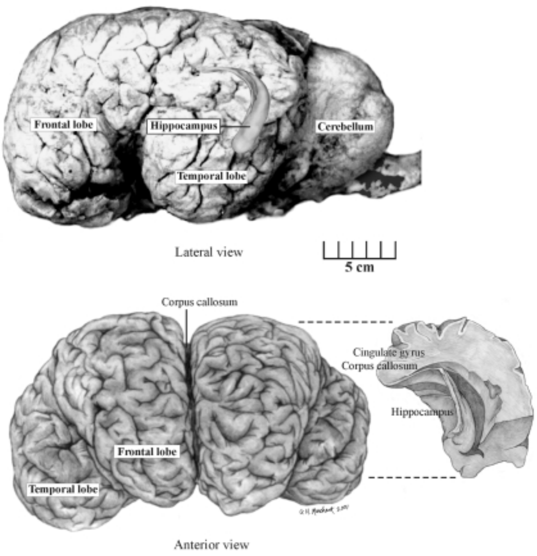


Fig.1 - Location and orientation of the hippocampus in the medial temporal lobe (*Elephas maximus*).

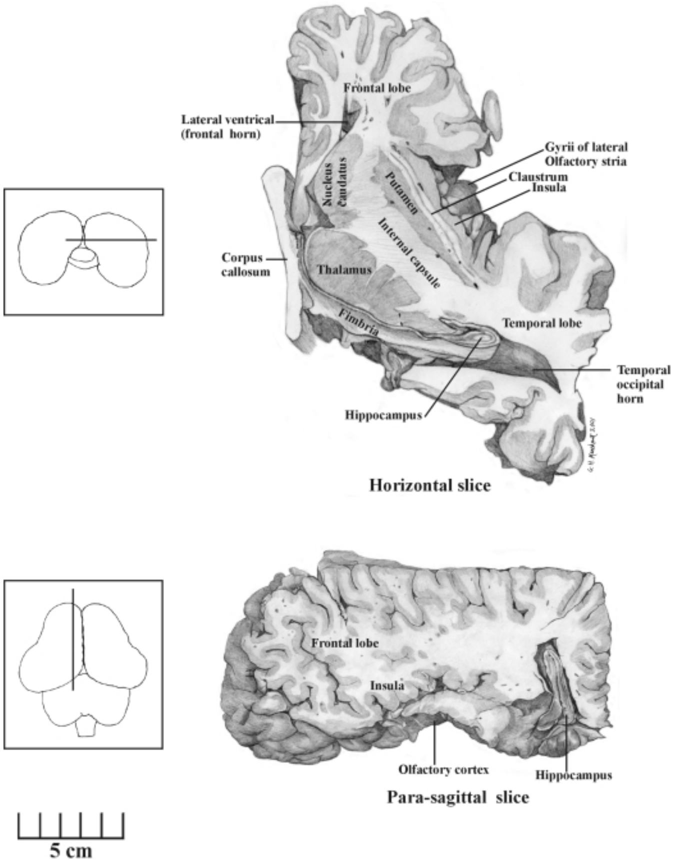
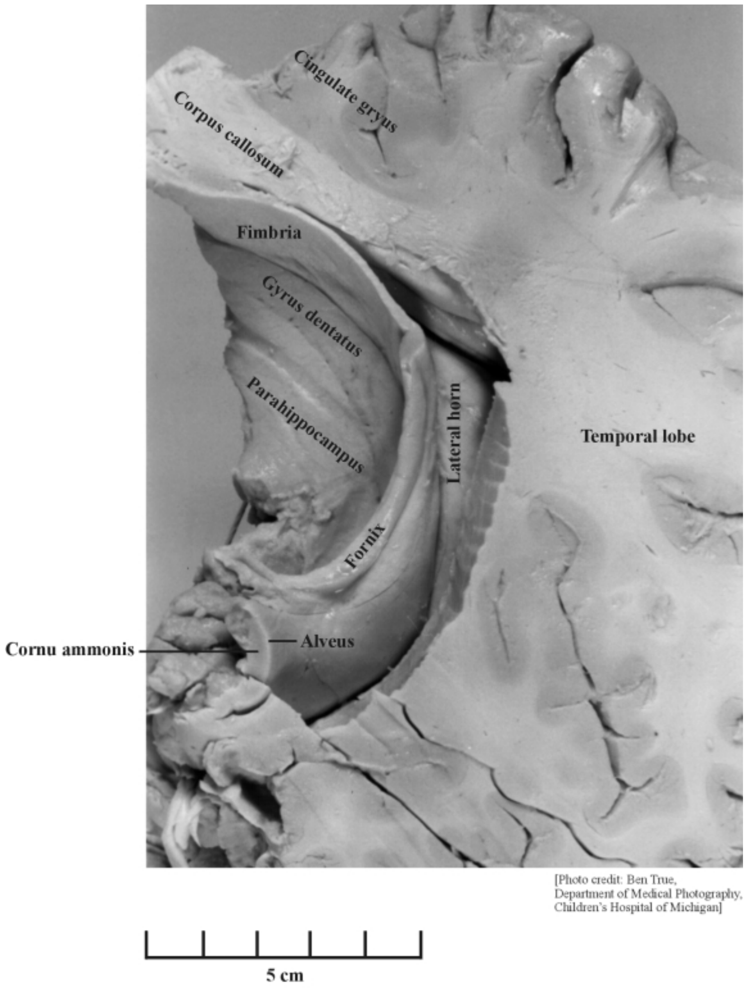


Fig.2 - Location and orientation of HC (*Loxodonta africana*). Note relationship of HC to medial wall of lateral ventricle.

3. RESULTS

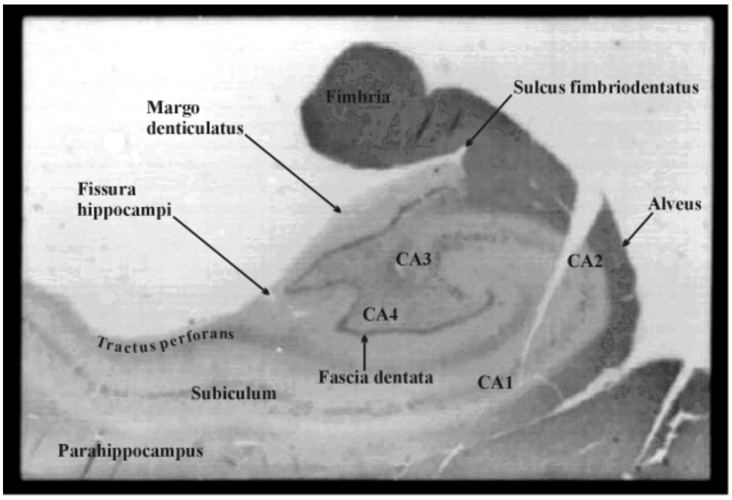
In both elephant specimens, the HC was identified in the medial temporal lobe oriented parallel to the long axis of the lobe (Fig. 1) and forming part of the medial wall of the inferior horn of the lateral ventricle (Fig. 2). The HC was approximately the same size as the human HC but small relative to the overall size of the elephant cerebrum. The shape was similar to the human HC but the digitationes hippocampi were indistinct.

The gyrus dentatus was relatively broad and flat and the fimbria was also relatively broader and thinner than the human fimbria. The white matter of the parahippocampal gyrus formed a prominent bulge on the medial floor of the temporal horn (Fig. 3). The elephant HC showed a similar pattern of folding to the human HC, but the folding was less compact in the end folium. The three-layered archicortical pattern was easily observed (Fig. 4), but the neuronal packing density appeared generally less than in the human HC and there was a clear distinction between the three-layered pyramidal area CA3 along the lateral border of the fascia dentata (FD) and a layer of loosely arranged pyramidal neurons (CA4) within the end folium running



[Photo credit: Ben True,
Department of Medical Photography,
Children's Hospital of Michigan]

Fig.3 - Detailed photograph of HC (*Elephas maximus*). The anterior portion of the *pes hippocampi* has been damaged. The fascia dentata is broad and flat. (Photographer: Mr. Benjamin True, Medical Photography).



[Photo credit: W. J. Kupsky]

Fig.4 - Low-magnification photomicrograph of mid-portion of HC sectioned perpendicular to the long axis of the HC. The f*ascia dentata* and zones of the *cornu ammonis* (CA) are marked. (Luxol fast blue/cresyl violet, 1x original magnification).

parallel to the FD. The FD consisted of a broad lamina moleculare, a compact lamina granulare of small bipolar neurons, and a narrow lamina plexiforme containing small cells. In the end folium, the distinct CA4 layer surrounded a central hilum of myelinated fibers devoid of neurons.

There was a distinct transition to pyramidal layer CA3. Ectopic pyramidal neurons in various orientations were prominent in both the lamina moleculare and lamina plexiforme. Pyramidal layers CA1 and the subiculum were distinguished by the presence of discrete sublaminae, with a compactly arranged layer of pyramidal cells forming the top of layer 2. Scattered large pyramidal neurons were relatively abundant in layer 1. Layer 3 included more abundant pyramidal neurons intermixed with small horizontally oriented neurons, most prominent in the subiculum.

No evidence of Alzheimer-type changes (senile plaques, neurofibrillary tangles-NFT, Hirano bodies, or granulovacuolar degeneration) or other aging changes such as prominent accumulation of lipofuscin, mineralization of the HC microvasculature, or vascular sclerotic change was noted in either hippocampal specimen.

4. CONCLUSIONS

HC structures in the elephant appear grossly and histologically to have the same basic structural components and anatomic disposition as in the human HC. The elephant HC, however, is about the same size as the human HC and is therefore smaller in proportion to the overall brain size (Fig. 5). The homologies have possible implications for similar functions (learning, memory, control of behavior). The absence of HC degenerative changes of the Alzheimer type (senile plaques, NFT, Hirano bodies, granulovacuolar degeneration.), which occur in the HC of many elderly humans as well as in humans with Alzheimer's disease is of uncertain significance.

Degenerative changes were not noted in three older elephant brains examined by Cole & Neal (1990). Although the ages of the elephants we examined (34 and 46 years) may only represent somewhat more than half of their maximal life span potential, the African elephant did show rare NFT in the substantia nigra, a non-limbic brainstem structure involved with NFT in other forms of human neurodegenerative disease. This basic research is part of a long-term systematic study of ele-

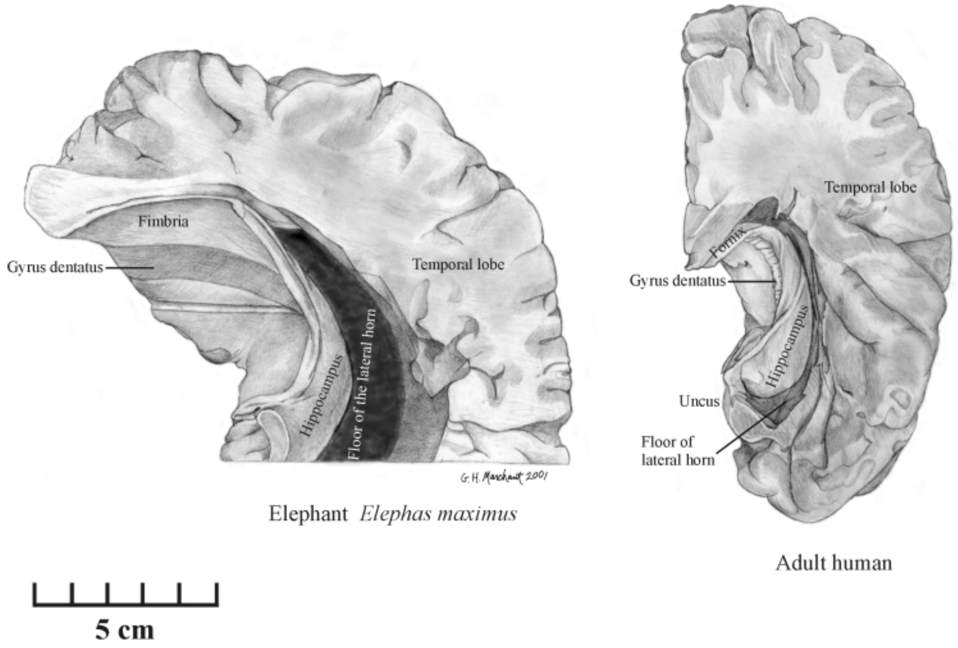


Fig.5 - Comparison of elephant and human hippocampus drawn to same scale.

phant brain anatomy from both a macroscopic and microscopic perspective whose goal is to fill in missing or misunderstood information using a holistic approach to gain knowledge on the largest living land mammal.

5. REFERENCES

Cole, G. & Neal, J.W. 1990. The brain in aged elephants. *Journal of Neuropathology and Experimental Neurology* 49: 190-192.

Dexler, H. 1907. Zur Anatomie des Zentralnervensystems von *Elephas indicus*. *Arb. neur. Inst. Wein* 15:137-281.

Haug, H. 1970. Der makroskopische Aufbau des Grosshirns; Qualitative und quantitative Untersuchungen an den Gehirnen des Menschen, der Delphinoideae und des Elefanten. *Ergebnisse der Anatomie und Entwicklungsgeschichte* 43(4): 3-70.

Janssen, P. & Stephan, H. 1956. Recherches sur le cerveau de l'elephant d'Afrique (*Loxodonta africana* Blum.). I. Introductions et considerations macroscopiques. *Acta neurologica belgica* 56: 731-757.

Koikegami, H., Kido, S. & Mayeda, Y. 1941. Zum Riechhirn des indischen Elephanten. *Gegenbaurs morphologisches Jahrbuch* 85: 512-524.

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“Gradual” evolution and molar scaling in the evolution of the mammoth

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SUMMARY: The assumption of gradual, directional change in molar morphology through the mammoth lineage has to be tested using samples dated independently of molar morphology itself. Moreover, lamellar frequency can be a misleading index of evolutionary advancement if molar size is changing at the same time. In the transition from *M. trogontherii* to *M. primigenius* in Europe, gradualistic increase in lamellar frequency is due to size reduction compressing molar plates. Plate number, a better index of evolutionary advancement, shows stasis around c. 500-200 ka BP, followed by a rapid shift to *M. primigenius* morphology.

Mammoths were continuously present in continental Eurasia from c. 2,6 Ma ago until the end of the Pleistocene. During that time they underwent very significant evolutionary change, including a shortening and heightening of the cranium and mandible, increase in molar hypsodonty, increase in plate number, and thinning of molar enamel. Based on these changes, European mammoths have conventionally been divided into three chronospecies: Early Pleistocene *Mammuthus meridionalis*, Middle Pleistocene *M. trogontherii* and Late Pleistocene *M. primigenius* (Maglio 1973; Lister 1996).

This evolutionary sequence, moreover, has frequently been presented as a paradigm of ‘gradualistic evolution’ (Gould & Eldredge 1977). Adam (1961), for example, assumed a sequence of ever-progressing ‘transitional forms’ between the three type species. There are also many examples in the literature where the logic is inverted and fossil deposits are dated on the basis of the evolutionary ‘level’ of the mammoths. Most recently, Vangengeim and Pevsner (2000) have given an account of European mammoth evolution which represents an extreme case of gradualistic methodology. They take upper third molar samples from eight sites spanning the interval c. 2.5 – 0.02 Ma, and calculate mean lamellar frequency (LF) for each. On the assumption that the evolution of this character follows an ‘area-cotangent law’, a mathematical curve relating LF to geological age is fitted to three of the samples whose ages are regarded as independently known. The ages of the other samples are then calculated from their lamellar frequencies, using the equation of the curve, and they are plotted on the graph where, of necessity, they all fall precisely along the line. This procedure produces some unexpected ages for well-known Quaternary deposits, for example Mosbach (dated to the early Middle Pleistocene, c. 500 ka: Koenigswald & Heinrich 1999) at c. 270-300 ka; Ilford (dated to OIS 7, c. 200 ka: Bridgland 1994) at 80 ka; Balderton (dated to OIS 6, c. 150 ka: Brandon & Sumbler 1991) at 32 ka.

A feature of these and other studies has been the use of lamellar frequency (or its reciprocal, length-lamellar quotient) as an index of evolutionary progression. Very broadly, as the number of plates in mammoth molars increased through time, their packing became denser, and so lamellar frequency increased. But the way in which LF is defined means that it can be influenced not only by the number of plates but also by the size of the tooth (Lister & Joysey 1992). In the formula LF = N/L, where N is a number of plates and L the length of molar they occupy, LF will increase if N goes up but also if L goes down. In other words, samples with the same number of plates in the molar will show altered LF if molar size varies (Fig. 1).

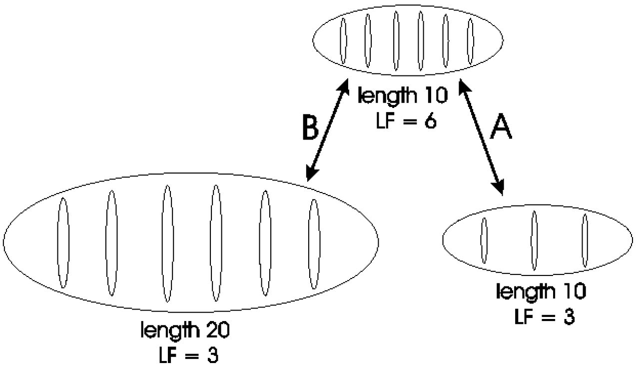

Fig.1 - Diagram illustrating how lamellar frequency (LF) can be altered both by (A) the addition or subtraction of plates, and (B) an increase or decrease in molar size. Lengths given in cm; LFs calculated as the number of plates in 10 cm of crown (10N/L).

A clear example of this is seen in Middle Pleistocene mammoths in Europe. The early Middle Pleistocene *M. trogontherii* was of extremely large size, and a progressive size decrease can be measured from Süssenborn and Mosbach (c. 600-500 ka), through Steinheim (c. 350 ka BP), to OIS 7 sites such as Ilford and Ehringsdorf (c. 200 ka), samples of the latter age being of unusually small molar size. It is possible to calculate, from the degree of size reduction alone, the expected compression effect on the plates and hence the expected elevation of LF (Lister & Joysey 1992). This calculation shows that the LF increase through this part of the sequence (Fig. 2) is due entirely to size reduction; there is no residual effect attributable to increase in plate number.

This pattern of stasis through the Middle Pleistocene can be confirmed by plotting raw plate number (P) against time, based on independently dated samples, whence it is seen that there is little or no increase in P through the interval c. 600-200 ka (Lister & Joysey 1992; Lister & Sher, in press), the mean remaining constant at around 19 plates in M3 (Fig. 2). The increase in LF is a real phenomenon, and may have had implications in terms of molar function – shearing adaptation is affected by closeness of lamellar packing (Maglio 1973). But it does not, when caused by size reduction, represent evolutionary change in the morphological or developmental sense. The later, smaller teeth are merely isometrically scaled replicas of the earlier, larger ones. Plate number is a more meaningful measure of evolutionary advancement, as it reflects genuine morphological and developmental change. Lamellar frequency can be a valuable index of plate num-

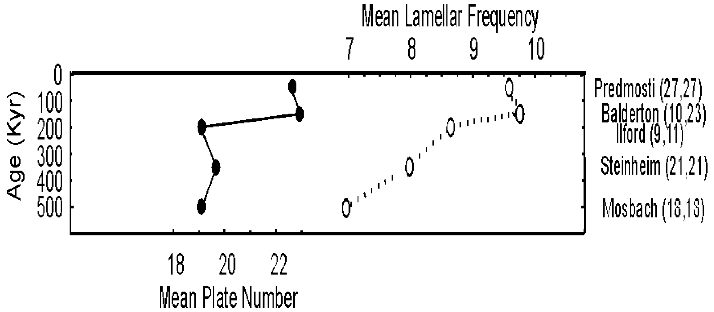

Fig.2 - Plot of mean plate number (P) and lamellar frequency (LF) of M^3s in the *Mammuthus trogontherii – M. primigenius* lineage. The stasis in plate number Mosbach – Steinheim – Ilford is evident, while lamellar frequency increases, due to size reduction. Sample sizes (P, LF) in brackets.

ber, as the latter requires complete molars whereas LF does not and is almost always measurable on a larger sample of teeth. However, it is a reliable index of evolutionary advancement *only if molar size remains constant*, or if size changes can be factored out (Lister & Joysey 1992).

The Late Middle Pleistocene interglacial age (cf. OIS 7, 200 ka) of the Ilford sample has been well-established on the basis of geomorphology (Bridgland 1994), amino-acid racemisation (Bowen *et al.* 1989) and mammalian biostratigraphy (Schreve, in press). Its unlikely reallocation to c. 82 ka by Vangengeim and Pevsner (2000) is based on an elevated LF which, according to our analysis, is produced entirely by size reduction. Plate number, the true index of evolutionary advancement, has remained at *M. trogontherii* levels.

Since the other main variable in mammoth molar evolution, hypsodonty index, had reached its full and final extent by late *M. trogontherii* c. 500 ka (Lister 1996), late Middle Pleistocene mammoths in Europe (c. 450-200 ka) resemble *M. trogontherii* in both key aspects of molar morphology, differing mainly in reduced size. In most accounts (e.g. Dietrich 1912 for Steinheim; Gromov & Garutt 1975 for Ehringsdorf) they are regarded as early forms of *M. primigenius*, based on elevated LF. A late survival of *M. trogontherii* was, however, presaged by Dubrovo (1966) in her concept of late Middle Pleistocene '*Mammuthus trogontherii chosaricus*'.

After 200 ka, there is a switch in mammoth molar morphology, at least in NW Europe, to forms of typical *M. primigenius* morphology, with mean plate number of 23 or so in M3. Various samples of OIS 6 age (c. 150 ka) are indistinguishable from those of the Weichselian (last) glaciation.

Vangengeim and Pevsner (2000) challenge this finding, focussing in particular on the Balderton sample, since their model requires mammoth molars of this degree of advancement to be considerably younger than the published 150 ka age. They obtained a radiocarbon date of 29,600 +/- 600 BP (GIN-8734) on a mammoth bone from the locality, which fits their expectation of c. 32 ka calculated from lamellar frequency. However, three factors militate against this conclusion. First, the OIS6 age of the Balderton Sands and Gravels is strongly supported by an array of geological and biostratigraphic evidence, including geomorphology (its position in a terrace above Last Interglacial deposits), ESR dating of mammoth molar enamel, and biostratigraphy (fauna including Middle Pleistocene taxa) (Brandon & Sumbler 1991; Lister & Brandon 1991). Second, it is increasingly recognised that radiocarbon ages close to 30 ka can be obtained from samples which are in fact radiocarbon infinite (R.E.M. Hedges, pers. comm.). Third, a series of other European sites, independently dated to OIS 6, have also yielded fully-evolved *M. primigenius*. These include La Cotte, Jersey (Scott 1986); Zemst, Belgium (Germonpre *et al.* 1993); and Tattershall Thorpe, England (Holyoak & Preece 1980).

The presumed gradualistic transition in mammoth molars through the Middle and Late Pleistocene therefore appears instead rather rectangular in shape, at least in these characters, with a rather sudden replacement of *M. trogontherii* morphology by that of *M. primigenius* some time between c. 200 – 150 ka, but stasis (little evolutionary change) before and after that date (Fig. 2). Lister and Sher (in press) argue that this rapid changeover in Europe reflects the origin of *M. primigenius* morphology in NE Siberia, followed by its spread to Europe, where it replaced that of *M. trogontherii*.

The danger of assuming a particular pattern of evolution, and then imposing on the data, is that we will never allow the fossils to reveal a pattern of change different from the one expected at the outset. It will also lead to bad biostratigraphy if the 'evolutionary level' of a sample is used to date it on the basis of an untested, preconceived idea of evolutionary trends. The trends have to be established on the basis of independently (geologically) dated samples; they can then be used to determine evolutionary pattern or geological age (Lister 1992).

The extreme gradualist view exemplified by Vanengeim and Pevsner (2000), with a species condemned to evolve relentlessly in one direction over long periods of time, implies an 'internalist' view of evolution, recalling the orthogenesis of the 19th century, in which the motive force for change comes from within the animal. How could it be otherwise, if in the constantly changing world of the Quaternary a species managed to maintain an unstoppable, unidirectional evolutionary trajectory? Darwinian natural selection, on the other hand, an essentially externalist concept, would predict complex variations of rate and pattern in such a changeable environment.

References

Adam, K.-D. 1961. Die Bedeutung der pleistozänen Säugetier-Faunen Mitteleuropas für die Geschichte des Eiszeitalters. *Stuttgarter Beiträge zur Naturkunde* 78: 1-34.

Bowen, D.Q., Hughes, S., Sykes, G.A. & Miller, G.H. 1989. Land-sea correlations in the Pleistocene, based on isoleucine epimerisation in non-marine molluscs. *Nature* 340: 49-51.

Brandon, A. & Sumbler, M.G. 1991. The Balderton Sand and Gravel: pre-Ipswichian cold stage fluvial deposits near Lincoln, England. *J. Quat. Sci.* 6: 117-138.

Bridgland, D. 1994. *Quaternary of the Thames*. Geological Conservation Review Series 7 London: Chapman & Hall.

Dietrich, W.O. 1912. *Elephas primigenius Fraasi*, eine schwäbische Mammutrasse. *Jahresh. Ver. vaterl. Naturk. in Württemberg* 68: 42-106.

Dubrovo, I.A. 1966. Systematic position of an elephant from the Khozar faunal assemblage. *Byull. Kom. Izuch. Chetv. Per.* 32: 63-74 (in Russian).

Germonpre, M., Bogemans, F., van Neer, W. & Grün, R. 1993. The dating of two Pleistocene mammal assemblages from the Flemish Valley, Belgium. *Contr. Tert. Quatern. Geol.* 30: 147-153.

Gould, S.J.& Eldredge, N. 1977. Punctuated equilibria: the tempo and mode of evolution revisited. *Paleobiology* 3: 115-151.

Gromov, V.I. & Garutt, V.E. 1975. Mandibel-Reste einer Fruhform des Mammuthus primigenius (Blumenbach) von Weimar-Ehringsdorf. *Quartärpaläontologie* 1: 453-464.

Holyoak, D.T. & Preece, R.C. 1980. Late Pleistocene interglacial deposits at Tattershall, Lincolnshire. *Phil. Trans. R. Soc.,* B 311: 193-236.

Koenigswald, W.v. & Heinrich, W.-D. 1999. Mittelpleistozäne Säugetierfaunen aus Mitteleuropa – der Versuch einer biostratigraphischen Zuordnung. *Kaupia* 9: 53-112.

Lister, A.M. 1992. Mammalian fossils and Quaternary biostratigraphy. *Quaternary Science Reviews* 11: 329-44.

Lister, A.M. 1996. Evolution and taxonomy of Eurasian mammoths. In: J. Shoshani, & P. Tassy, (eds.) *The Proboscidea*: 203-213. Oxford: OUP.

Lister, A.M. & Brandon, A. 1991. A pre-Ipswichian cold-stage mammalian fauna from the Balderton Sand and Gravel, Lincolnshire, England. *J. Quat. Sci.* 6: 139-157.

Lister, A.M. & Joysey, K.A. 1992. Scaling effects in elephantid dental evolution – the example of Eurasian *Mammuthus*. In P. Smith, & E. Tchernov, (eds.) S*tructure, Function and Evolution of Teeth:* 185-213. Jerusalem: Freund.

Lister, A.M. & Sher, A.V. in press. The origin and evolution of the woolly mammoth. *Science*.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.* 63: 1-149.

Schreve, D.C. in press. Differentiation of the British late Middle Pleistocene interglacials: the evidence from mammalian biostratigraphy. *Quaternary Science Reviews*.

Scott, K. 1986. The large mammal fauna. In P. Callow, & J.M. Cornford, (eds.) *La Cotte de St Brelade 1961-1978: Excavations of CBM McBurney*: 159-183. Norwich: Geo Books.

Vangengeim, E.A. & Pevzner, M.A. 2000. Biometric dating of elephants of the *Archidiskodon-Mammuthus* lineage. *Stratigraphy and Geological Correlation* 8: 77-83.

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A reconstruction of the facial morphology and feeding behaviour of the deinotheres

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SUMMARY: The skull morphology of the deinotheres suggests that they had no elephantine trunk. Instead, they had a large, broad and overhanging muscular structure resembling, to a certain extent, the trunk of the tapir and used for browsing. Deinotheres lost early in their evolution the “salad tongs” food-gathering apparatus of primitive proboscideans.

Deinotheres are a bizarre and ultra-conservative proboscidean group, unique in lacking upper tusks while preserving the lower ones. The absence of known direct ancestors contributes to the enigmatic aura of this family. The deinotheres seem to emerge from nowhere, persist for about 20 Ma and then disappear without splitting into numerous phyletic lines or significantly changing their appearance, except in respect of their size.

From an ecological viewpoint, this means that the deinotheres were so well adapted to their particular niche that there was no stimulus to cause them to evolve drastically. What, however, was this niche?

Deinotheres became known to science more than 150 years ago. Since then, the ideas about their appearance and mode of life have changed more than once. They were initially thought to be rhinos, giant tapirs, sirens (using their tusks as an anchor while sleeping), whales and even marsupials (see Shoshani *et al.* 1996 for a more detailed review). Only after the discovery of postcranial remains, deinotheres were included among the relatives of elephants. During the twentieth century, however, the “elephantization” of the deinotheres went too far. The best known, broadly established reconstruction of these animals, originally stemming from Abel (1922), shows them as little more than elephants with lower tusks.

We believe that this reconstruction, featuring a lower lip situated immediately under the elephantine trunk, with tusks protruding from the chin is rather improbable both from an anatomical and an evolutionary point of view. It seems logical to suppose that in the still unknown “proto-deinotheres” the small lower tusks were more or less horizontally positioned with the lip in its usual place below them. It is much easier to imagine the curving of the mandible downwards with the lip retaining its position, than a complicated process during which it “migrated” over the tusks. Thus, the anterior surface of the deinothere tusks should correspond to the lingual surface of the basic mammal incisors, and the posterior surface to the labial one. The visible trough on the anterior surface of the symphysis, indicating a strong muscular tongue (as noted by Svistun 1974), also precludes a lower lip situated immediately in front of the cheek teeth.

As for the long elephantine proboscis of the deinotheres, its existence was doubted for anatomical reasons by several authors such as Svistun (1974), Tarabukin (1974), Harris (1975) and Tassy (1998).

We agree that the deinotheres probably didn't have a long, elephant-like trunk. Despite the large nasal opening, usually assumed to guarantee the presence of a trunk (see for example Vaufrey 1958), the general structure of the skull

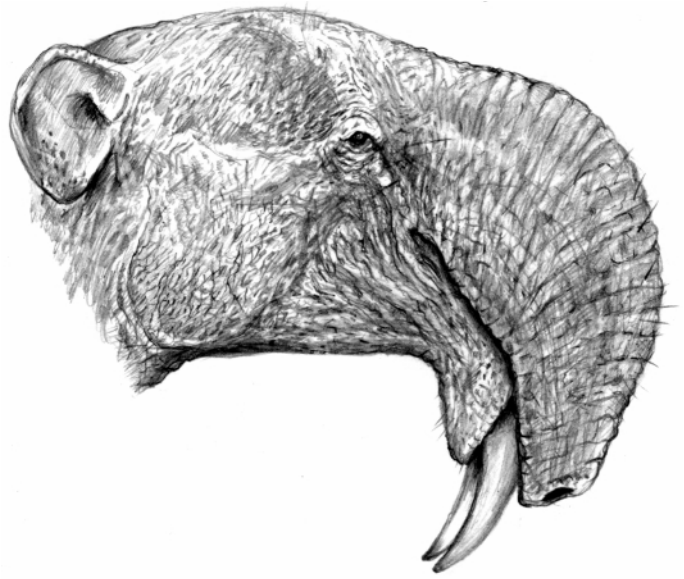

Fig.1 - Reconstruction of the head of *Deinotherium giganteum* (Drawing: Velizar Simeonovski).

speaks against it. As already pointed out by Tarabukin (1974), the deinothere skull provides no sufficient insertion surface for a typical elephantine proboscis. The large, more or less horizontally positioned premaxillae would be a hindrance rather than help to an operating cylindrical trunk.

A complicated and still debatable problem is the use of tusks. Harris (1975) gave good enough reasons against their use as levers or for digging. As was pointed out by the same author, there is no data indicating apparent sexual dimorphism, and the most important role of the tusks should be related to feeding. Despite the lack of a consistent wear pattern, the presence of wear facets on the medial or caudal sides of some deinothere tusks (K. Huttunen, pers. comm.) seems to support the idea that tusks were used when feeding in tree crowns.

The deinothere's cheek teeth obviously indicate that it fed on succulent tree vegetation and lived in forest habitats, browsing on the higher branches of the trees. It was, in a sense, "the tapir of the upper floor". Later, with the aridification of the climate, the deinotheres probably inhabited hygrophilous forests and forest patches. It could be supposed that they had to cover vast territories which led to locomotory adaptations in the distal segments of their limbs (see Tobien 1962).

As already said, the deinotheres fed in tree crowns. With its tusks the deinothere could remove the larger obstructing branches (but not pull down branches to mouth level as supposed by earlier authors), reach out with its "proboscis" (see below) and put the foliage into its mouth, onto the long horizontal part of the symphysis. There, the food would have been manipulated by the long muscular tongue. Such a mode of feeding seems to be supported by the adaptations of the occipital region for increased mobility of the head noted by Harris (1975). We agree with this author that the downward-curving of the tusks was related to the need to keep them out of the way while gathering food - their position and the loss of upper tusks permitted direct contact with the food source. In this position however, they still had a function in the gathering of food and remained fully functional during the evolutionary history of the family.

Early proboscideans like Oligocene *Phiomia* and *Palaeomastodon* (as well as many other Palaeogene large forest browsers) had a food-gathering apparatus in which the two pairs of incisors played a role similar to that of "salad tongs”. During the evolution of elephantoids, with the development of a proboscis and the elevation of the skull, the tusks lost their initial feeding-related function, lower tusks were lost in many elephantoid lineages (also the mandible was shortened) and the upper ones became perigamic structures. The deinotheres were the only proboscideans that lost their superior tusks, but they also shortened their mandible by curving it downward. Here, the function of the “salad tongs” was taken by the upper lip, the muscular tongue and the long horizontal part of the symphysis.

Harris (1978) noted that juvenile deinothere tusks had a different shape compared to the tusks of adult animals. It seems logical to suppose that juvenile deinotheres had also a somewhat different feeding behaviour due to their small size.

Additionally, the tusks of the deinotheres could also have a social function (as with all proboscidean tusks), related to intraspecific competition.

Our reconstruction (Fig. 1), based on the Eppelsheim skull of *Deinotherium giganteum*, shows an animal with a large muscular upper lip, laterally hanging over the lower one. This structure may be called a proboscis, because it is a result of the fusion of the tissues of the nose and the upper lip; but it is more a tapir-like proboscis than an elephantine trunk - cylindrical and fit for complicated operations, including with its tip.

As with the proboscis of the tapir, the deinothere's nostrils must have been situated on the tip. Thus the olfactory contact with the substratum is preserved. If the nostrils were situated immediately below the premaxillae, and only the upper lip was elongated (as with the black rhinoceros), the distance between the nostrils and the tip of the lip would hinder their olfactory function. In other words, the deinothere would not be able to use its sense of smell when in contact with its food. Another argument against such a position of the nostrils was given by Harris (1975.) The third possibility - that the nostrils were on the anterior surface of the lip, near its tip - seems to us highly improbable from the point of view of the anatomy of the cartilages of the nasal region.

We have to admit that, except for the position of the nostrils, our reconstruction strongly resembles Osborn’s initial restoration (Osborn 1910), which he later abandoned for no apparent reason, preferring the reconstruction by Abel (Osborn 1936). Our analysis has convinced us that Osborn’s original, practically forgotten concept was more realistic than later and better-known reconstructions.

CONCLUSIONS

Usually portrayed as curious elephants with misplaced tusks, deinotheres were in fact a group highly specialized in their feeding behaviour and narrowly adapted to a specific forest niche; a group that followed its own distinct and original evolutionary path for more than 20 Ma. After almost a century, evidence seems to revive H. F. Osborn’s abandoned and nearly forgotten initial concept of the deinotheres’ appearance.

REFERENCES

Abel, O. 1922. *Lebensbilder aus der Tierwelt der Vorzeit*. Jena.

Harris, J.M. 1975. Evolution of feeding mechanisms in the family Deinotheriidae (Mammalia: Proboscidea). *Zool. J. Linn. Soc.* 56: 331-362.

Harris, J.M. 1978. Deinotherioidea and Barytherioidea. In V. J. Maglio & H. B. S. Cooke (eds.) *Mammalian Evolution in Africa*: 315-332. Cambridge, Mass. Harvard University Press.

Osborn, H.F. 1910. *The age of mammals in Europe, Asia and North America*. New York: MacMillan.

Osborn, H.F. 1936. *Proboscidea,* New York: American Museum of Natural History.

Shoshani, J., West, R.M., Court, N., Savage, R.J.G. & Harris, J.M. 1996. The earliest proboscideans: general plan, taxonomy, and palaeoecology. In J. Shoshani & P. Tassy (eds.) *The Proboscidea. Evolution and Palaeoecology of Elephants and their*

Relatives: 57-75. Oxford: Oxford University Press.

Svistun, V.I. 1974. *Deinotheres of Ukraine*. Kiev: Naukova Dumka. (In Russian).

Tarabukin, B.A. 1974. New data on the systematics, phylogeny and ecology of Suborder Deinotherioidea Osborn (1921). In *Mammals of the late Cenozoic from south-western USSR*: 77-90. Kishinev: Shtiintsa. (In Russian).

Tassy, P. 1998. Et la trompe vint aux éléphants. *La Rechèrche* 305.

Tobien, H. 1962. Über Carpus und Tarsus von Deinotherium giganteum Kaup (Mamm., Proboscidea). *Paläont. Zeitschr., H. Schmidt-Festband*: 231-238.

Vaufrey, R. 1958. Proboscidiens. Étude Systématique. In J. Piveteau (ed.), *Traité de Paléontologie, Tom VI, vol. 2*: 203-295. Paris: Masson & Cie.

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Schreger lines as support in the Elephantinae identification

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SUMMARY: The tusk of Elephantidae representatives is constituted by a serial of cones of dentine, which are formed progressively during the ontogenetic development and have been radials crossed by tubule bundle, carrying blood. Every transversal cross-section of tusk, cutting the tubules, generates a pattern of two set of lines curving clockwise and counterclockwise that form a typical. Different tubule trends can be observed starting from initial stage (apex) to final stage (rings with maximal radius) of tusk. Consequently, the wideness of rhomboid-shaped figure angles increases from central to peripheral area of the tusk; the different increasing rates allow to discriminate the Elephantinae taxa. This research should like to establish the range of variation in *Loxodonta, Elephas* and *Mammuthus* representatives and the main differences among Schreger patterns of the three genera.

1. FOREWORD

The "Schreger lines", described for the first time by time by Bernhard Gottlob Schreger in the 1800 (Obermayer 1881) are a peculiar character of the Proboscidean dentine. They are evident in transversal cross-section of tusk and are due to sinusoid trend of dentinal tubules: when the waves, formed from these tubules, have intercepted by the cut-surface on the transversal section, the interception point sequences form two different sets of lines that curve clockwise and counterclockwise. The crossing of these lines form several outer and inter angles here called Schreger angles. According to the different calibre of tubules, we can distinguish more evident Schreger lines, near dental-cement surface and less clear ones, near pulp cavity (Espinoza *et al.* 1990).

Our research has as main object to study the trend of Schreger lines in the subfamily Elephantinae, try to test their taxonomic value and to establish the range of variation in *Loxodonta, Elephas* and *Mammuthus* representatives and the main differences among Schreger patterns of the three genera.

Furthermore, we have made a preliminary comparison with other genera, no closely to subfamily Elephantinae, like *Anancus* and *Stegodon* (Palombo & Villa 2000).

2. MATERIALS AND METHODS

We have collected and examined 480 specimens of tusks, but it was possible to get reliable measurement of Schreger angles in only 238 specimens, belonging to the following species: *Loxodonta africana* (72 specimens); *Elephas maximus* (17); *Mammuthus primigenius* (49); *Mammuthus meridionalis* (20); *Mammuthus trogontherii* (10); *Mammuthus* sp. (6); *Elephas (Palaeoloxodon) antiquus* (28); *Elephas falconeri* (4); *Anancus arvernensis* (31); *Stegodon* (9). The specimens belonging to extant species are both tusk and miniature sculptures or souvenir in ivory.

The 70% of samples were examined using a video camera and then all of tusks were listed in a computer. Each image was studied with the software CV9000. This software allow to measure almost Schreger angles, with precision of 93%-95%.

Then, five concave angles and five convex angles were measured for each specimen, both in proximity to dentine-cement surface and to pulp cavity.

3. DISCUSSION

The first step of analysis allow to better understand the factors, which affect both Schreger line trends and, consequently, angle width. Schreger lines with wide bending radius correspond to sets of dentinal tubules with the distance between two adjacent nodes that increases in each cone, from more recent one to older generation. Schreger lines with short bending radius correspond to sets of dentinal tubules with the distance between two adjacent nodes decreases (Fig. 1).

Two major Schreger patterns can be detected: one is characterised of genera *Loxodonta* and *Elephas*; the other one is characterised of genus *Mammuthus* (Fig. 2).

In *Loxodonta africana*, it is possible to show two types of sections: one correspond the last generation cones, where the Schreger inter angles (in proximity to pulp cavity) are narrow (48°-88°), and the Schreger outer angles (in proximity to dentine-cement surface) are wide (118°-145°). The other one corresponds to the first generation cones, where the bending radius is kept constant and the Schreger angles are wide in the sub-central area of tusk, yet.

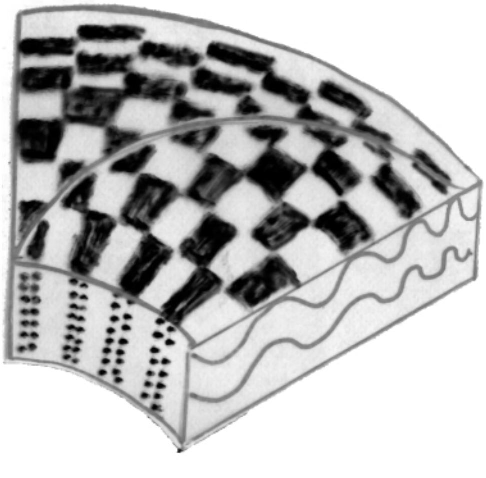

Fig.1 - Cross section with lines drawn through the dark areas (section of tubules nodes) to emphasise the curved natura of Schreger lines and radial section showing undulated curvatures of the dentinal tubules.

In *Elephas maximus, Elephas (Palaeoloxodon) antiquus* and *Elephas falconeri* the distribution pattern of Schreger angles is comparable to *Loxodonta africana* (Fig. 3).

In *Mammuthus primigenius*, *Mammuthus meridionalis* and *Mammuthus trogontherii* the Schreger lines diverge from section radius not so much, both the first generation and last generation cones. Therefore, the Schreger angles are narrower than in genus *Loxodonta*, especially in the peripheral area of tusk (in proximity to dentine-cement surface) (Fig. 3).

Moreover, the Schreger lines network can change during the ontogenetic grow, so different section of a given tusk might be quite different.

For example, the study of transversal serial sections of *Loxodonta africana* has allowed to show that the part of tusk corresponding to young stage (distal part) is characterised from very curved Schreger lines, with almost constant bending radius. The sections of last formed part of the tusk (proximal part), instead, exhibit important differences of bending radius from central part to circumference. All this is explained by different trend of dentinal tubules due to a change of different distances between adjacency nodes along the same tubule as well as in different parts of every cone. In fact, each dentinal tubule is characterised from a wave of nodes and antinodes alternated long tubule. The more nodes are near each other, the more virtual lines, formed from all of sections, will trend to curve; and in this way, these lines will go away radius of tusk sections and will have a trend almost parallel to circumference. After the analysis of serial sections of *Loxodonta africana*, in the last generation cones the distance between adjacency nodes, called wavelength, is relatively width at the apex and then it strongly decreases, in proximity to dentine-cement interface. In the first generation cones,

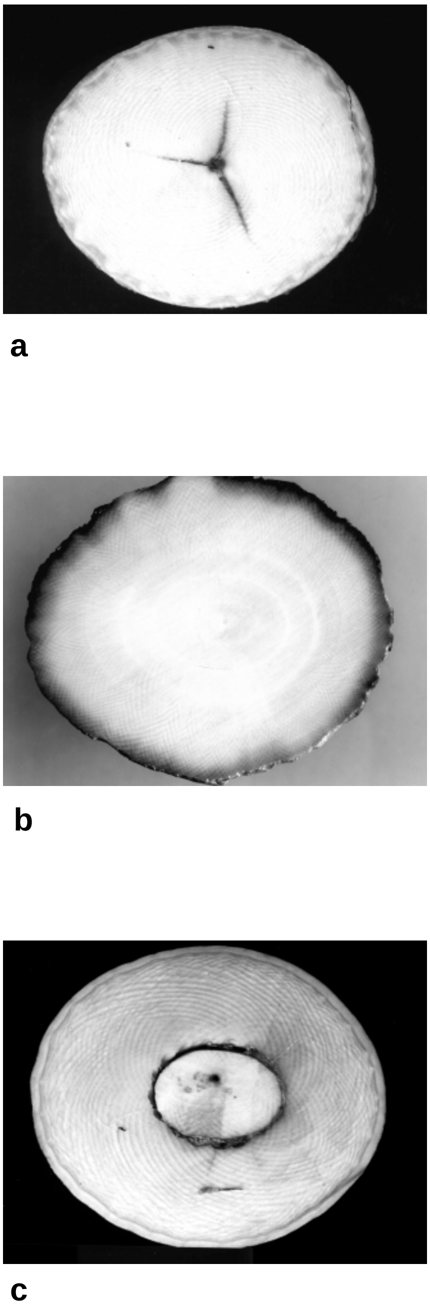

Fig.2 - Cross section of tusks. a) *Loxodonta africana*, b) *Mammuthus primigenius*, c) *Elephas maximus*.

the wavelength is already short from apex of cone. Therefore, in transversal section the optical effect form the Schreger lines is different in the nearest sections to apex and the bending radius is almost constant; with lines that progressively move away from radius of sections. On the contrary, in the proximal sections, the Schreger lines are less curved at last, and they are formed a rhomboid pattern with maximal diagonal in according to the radius of tusk.

In transversal sections of *Mammuthus primigenius*, the wavelength of dentinal tubules, independently by their generation, undergoes a lower decrease as to *Loxodonta africana*. Consequently, the high bending radius of Schreger lines in all species of *Mammuthus* studied (*Mammuthus primigenius; Mammuthus meridionalis; Mammuthus trogontherii*) could be the cause of narrow Schreger outer angles.

The complete separation of two different variability ranges of Schreger angles measured near the dentine-cement surface, one for *Loxodonta africana* (118°-145°), the other for *Mammuthus primigenius* (65°-90°), is due to Schreger lines trend (Fig. 3).

In fact, in *Loxodonta africana* the Schreger lines follow the section radius only for short distance, and then they diverge and have a parallel trend to tusk circumference. In *Mammuthus primigenius* the Schreger lines follow the section radius for long distance, and they diverge from it in the peripheral part only. This different Schreger lines trends explains the evident difference between the width of *Loxodonta africana* Schreger outer angles and width of *Mammuthus primigenius* Schreger outer angles (Fig. 1).

Moreover, excluding the apex of tusk, the degrees of Schreger inter (in proximity to pulp cavity) angles of *Loxodonta africana* are similar to degrees of Schreger outer (in proximity to dentine-cement surface) in *Mammuthus primigenius*. This would make very difficult to distinguish two types of ivory between them on the basis of Shreger angles only, therefore the rhomboidal figures resulting by Schreger line crossing is quite different.

A preliminary comparison have been made among the species of subfamily Elephantinae

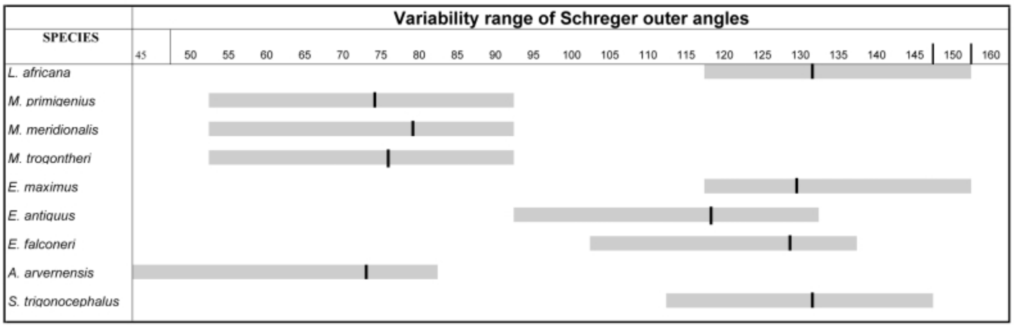

Fig.3 - Variability ranges of Schreger outer angles.

and two other species of different subfamily like *Anancus arvernensis* and *Stegodon trigonocephalus*. Even if with the caution due to the scanty number of samples, it seems that the averages wideness of Schreger angles in *Anancus arvernensis* is very close to genus *Mammuthus*. In fact, the bending radius of Schreger lines in *Anancus* is constant, independently from different generations, long all tusk sections. In *Anancus arvernensis*, therefore, the mean of Schreger outer (in proximity to dentine-cement surface) angles is the same to mean of Schreger inter (in proximity to pulp cavity) angles. On the contrary, the means of Schreger angles in *Stegodon trigonocephalus* are similar to means of Schreger angles in *Loxodonta africana* (Fig. 3).

4. Conclusive remarks

The analysis of Schreger lines trend can constitute a valid support to Elephantinae genera identification especially when other identifiable osteological samples are not available; although the possibility of identification widely change according to dimension, growing stage, anatomical position of the investigated section, fossilisation of tusk fragment et cetera.

Moreover, the data collected show that the Schreger angles and lines are not sexual characters. The observation on tusks of different individuals, both old and young, shows that especially in *Loxodonta african*a the degree of Schreger angles depend of age.

Furthermore, to examine specimens of both extant and extinct taxa coming from different geographic area, remarks that the environmental factor is not influence on the Schreger angles and trend of lines

The study of dentinal tubules trim and, consequently, of Schreger lines trend and Schreger angles width allow to distinguish two Schreger patterns: one is characterised of genera *Loxodonta* and *Elephas*; the other one is characterised of genus *Mammuthus*.

In fact, the comparison between *Loxodonta africana* and *Mammuthus primigenius*, two guide species, and other species studied has showed as: the widths of Schreger angles, in *Elephas maximus*, *Elephas (Palaeoloxodon) antiquus* are like widths of Schreger angles measured in *Loxodonta africana*. This should emphasise that genus *Loxodonta* is closer to genus *Elephas* as regard as this character considered.

The Schreger patterns can be a valid basis for taxonomic identification of Elephantinae genus, especially when the molars and other important parts of skeleton (skull) are incomplete or is very difficult to ascribe them. An increase in analysis and in data could be a valid help for taxonomic and phylogenetic studies about Proboscideans.

5. References

Espinoza, E.O. & Mann, M.J. 1992. Identification guide for ivory and ivory substitutes. *World Wildlife Fund Publication*.

Espinoza, E.O. & Mann, M.J. 1993. The history and significance of the Schreger pattern in Proboscidean ivory characterization. *Journal of the American Institute Conservation* 32: 241-248.

Espinoza, E.O., Mann, M.J., Lemay, J.P. & Oakes, K.A. 1990. A method for differentiating modern from Ancient Proboscidean Ivory in Worked Objects. *Current Research in the Pleistocene* 7: 81-83.

Fisher, D.C., Trapani, J., Shoshani, J., Woodford, M.S. 1998. Schreger angles in Mammoth and Mastodon tusk dentin. *Current Research in the Pleistocene* 15: 105-106.

Fox, D. & Fisher, D. 1994. Tusk growth rate Loxodonta africana as recorded by incremental laminae in tusk dentin. *Journal of Vertebrate Paleontology* 14: 26A.

Hillson, S. 1986. *Teeth (Cambridge manuals in archaeology)*. Cambridge: Cambridge University Press.

Obermayer, F. 1881. Beitrag zur kenntnis des zahnbeines vom elefanten, nilpferd, walross und narwal. *Verlag des Vereines der Weiner Handels-Akademic*: 102-113.

Palombo, M.R. & Villa, P. 2000. Schreger lines as support in the Elephantinae classification. *Abstract Congresso "Les Oungules Holarctiques du Pliocene et du Pleistocene", 19-22 Settembre 2000*, Avignone.

Villa, P. 2000. Le linee di Schreger nella sottofamiglia Elephantinae : risvolti tassonomici, filogenetici e per la tutela delle specie attuali *Loxodonta africana* e *Elephas maximus*. Unpublished dissertation, Università degli Studi di Roma "La Sapienza", 1999-2000.

Morphological differences in *Mammuthus meridionalis* and *Palaeoloxodon antiquus* carpal bones

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SUMMARY: *Mammuthus meridionalis* and *Palaeloxodon antiquus* carpal bones are described. The examination of some carpals and comparisons with material found in Italy has made it possible to highlight some of the typical characteristics of these two species.

1. INTRODUCTION

Excavations carried out in 1992 and 1993 gave some fundamental answers to enquiries posed after the discovery of the Paleontological remains in the Steggio zone (Possagno, Treviso, north-east Italy). It was possible to fill a stratographic time gap consisting of the apparent absence of evidence of a Quaternary era in a formation geologically defined Tertiary (Paronuzzi & Tonon 1992). In the Quaternary lacustrine site at Steggio many fossil bones were recovered, among which were various carpal bones of *Mammuthus (Archidiskodon) meridionalis* (Nesti 1825).

The topic of this study is an analysis of some carpal bones of pleistocene elephants. The examinations of the remains of Steggio (Reggiani 1999) and comparisons with the abundant material found at Castel di Guido (Sala & Barb 1996), Pietrafitta (Ambrosetti *et al.* 1987), Riano (Maccagno 1962) and Grotte Santo Stefano (Palombo & Villa in press) have made it possible to highlight some morphological difference between *M. meridionalis* and *Palaeoloxodon antiquus* (Falconer & Cautley 1847). The lignite deposits of Pietrafitta (Perugia, Central Italy) contain an important association of large mammals of the Early Pleistocene (Gentili *et al.* 1996). From this fossil bed abundant rests of *M. meridionalis* have been recovered. In addition, published material which will be referred to in the text has also been taken into consideration. Since the carpal bones are little described in the literatura, we found it appropriate to introduce some characteristic for distinguishing these two species of elephants.

2. ANATOMICAL DESCRIPTION

In the distal articular surface of all the unciforms we have studied, three facets of articulation for the third, quarter and fifth metacarpal are present.

In *M. meridionalis* the unciforms (n = 7) are proportionally tall and narrow, while in *P. antiquus* they are low and wide (n = 6), as can be seen in the figure 1. This difference is highlighted in figure 2, and in fact the values of the DT/H – DT/DAP relationship (Fig. 3) attribuited to *P. antiquus* can be separated from those pertinent to other species.

Therefore the inclination of the proximal articular surface of the unciform is also frequently greater in *M. meridionalis* (Fig. 1). The carpal of this last species is, moreover, proportionally deeper (Fig. 2).

The unciform of the ancient elephant from Notarchirico, as described and illustrated by Cassoli *et al.* (1999), and the one of Tsoukala & Lister (1998) have a form similar to that described here. Dubrovo (1988) admits that in the forest elephant this bone is relatively wide in comparison with other species.

In the magnum of *P. antiquus* the articular

Fig.1 - Unciform viewed dorsally, 1) *M. meridionalis* n. 309 from Pietrafitta, 2) *P. antiquus* n. 11740 from Castel di Guido, 3) *P. antiquus* from Grotte Santo Stefano (Palombo & Villa, in press), 4) *M. meridionalis* n. 159/b from Steggio.

facet for the trapezoid is united, while it is divided in *M. meridionalis*. In this second species the magnum is often taller than wider. These characteristics were pointed out by Ouadi & Bonifay (1998).

The trapezoids of *P. antiquus* from Cave Santo Stefano and from Riano, like those from Castel di Guido (Reggiani 1999), are proportionally long and narrow, while they are short and wide in the *M. meridionalis*. The plantar tuberosity, on which part of the facets of articulation with the scaphoid, magnum, trapezium and second matacarpus are present, is more developed and lengthened at the back in P. antiquus in comparison with other species (Fig. 4).

This difference is emphasized by the value of the relationship percentage DTd (trasversal diameter of the dorsal face) / DAPm (maximum

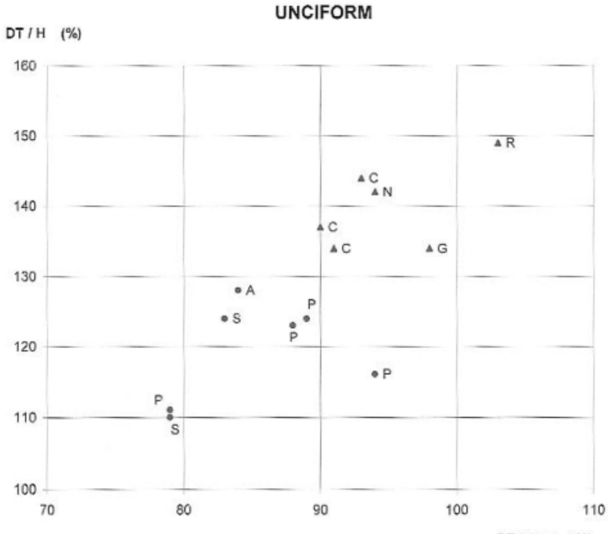

Fig.2 - The relationship between the ratio DT/DAP (trasversal diameter of the dorsal face / antero – posterior diameter of the achsial face) and the ratio DT/H (trasversal diameter of the dorsal face / maximum dorsal height) in *M. meridionalis* (circle) and *P. antiquus* (triangle) from Steggio (S), Pietrafitta (P), l'Aquila (A), Castel di Guido (C), Cave Santo Stefano (G), Notarchirico (N), Riano (R).

antero-posterior diameter) (Fig. 3). In the *P. antiquus* specimens (n = 4) this relationship varies between 56 and 64, while in the trapezoids of *M. meridionalis* (n = 4) it is 70-75. The trapezoid described and illustrated by Bonfiglio & Berdar (1986) also seems to have a form similar to that considered.

In general the bones of the first and second range of the carpus of *M. meridionalis* are narrower and taller than those of *P. antiquus*; the carpus is therefore slimmer in the former and stockier in the latter.

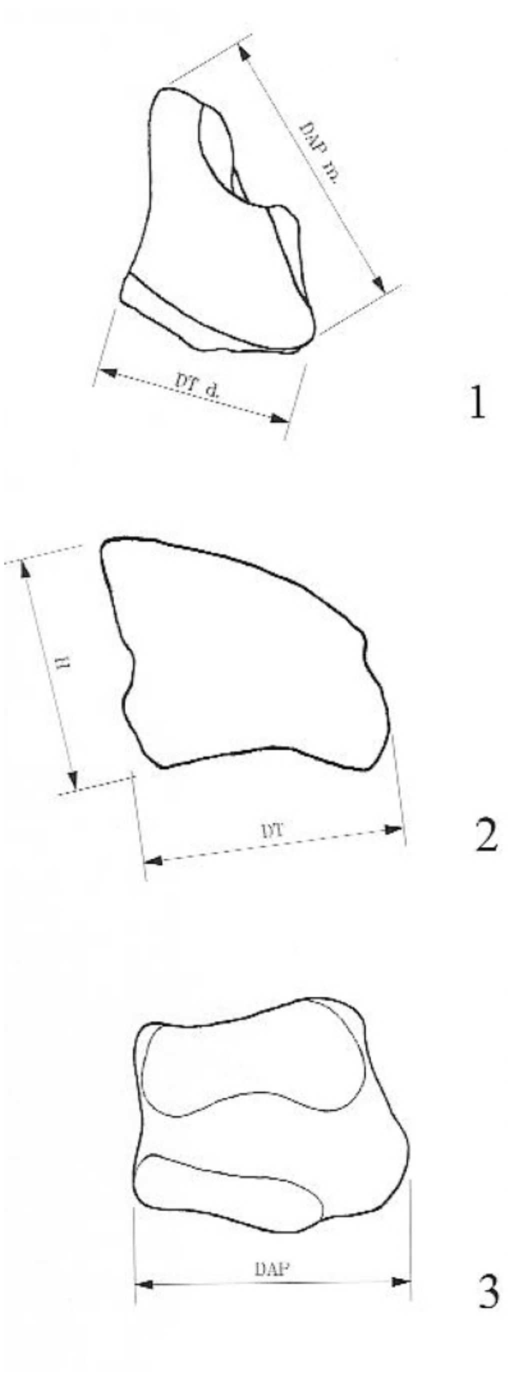

Fig.3 - Trapezoid in proximal view (1). Unciform dorsally viewed (2) and achsial viewed (3).

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I am particularly grateful to Proff. P. Ambrosetti, M.R. Palombo and B. Sala for having allowed me to analyse the finds from Pietrafitta, Castel di Guido which are housed at the Museum of the University of Rome. I would like to thank drs. S. Gentili and R. Manni for helping me during the study of the Umbrian and Rome collections. Finally, I would like to thank prof. M. Tonon and dr. L. Picin for having contributed to the result of this work.

4. REFERENCES

Ambrosetti, P., Faraone, A., Gregori, L. 1987. Pietrafitta: un museo di paleontologia in Umbria. *Museol. sci. IV* (1-2): 99-118.

Bonfiglio, L. & Berdar, A. 1986. Gli elefanti del Pleistocene superiore di Archi (RC): nuove evidenze di insularità della Calabria meridionale durante il ciclo Tirreniano. *Soc. Paleont. Ital.* 25 (1): 9-34.

Cassoli, P.F., Di Stefano, G., Tagliacozzo, A. 1999. I vertebrati dei livelli superiori (A ed ALFA) della serie stratigrafica di Notarchirico. In M. Piperno, (ed.), *Notarchirico. Un sito del Pleistocene medio-inferiore nel bacino di Venosa (Basilicata)* 1: 361-438. Venosa.

Dubrovo, I.A. & Jakubowski, G. 1988. The carpus morphology of the forest elephant (*Palaeoloxodon*) and its significance for taxonomy. *Prace Muzeum Ziemi Warszawa* 40: 65-83.

Fig.4 - Proximal view of a right trapezoid of *M. meridionalis*, n. 301 from Pietrafitta (1). Distal view of rapezoid of *P. antiquus* from Grotte Santo Stefano (2) and from Riano (3).

Gentili, S., Abbazzi, L., Masini, F., Ambrosetti, P., Argenti, P., Torre, D. 1996. Voles from the Early Pleistocene of Pietrafitta (central Italy, Perugia). *Acta zool. cracov.* 39 (1): 185-199.

Maccagno, A. M. 1962. Gli elefanti fossili di Riano (Roma). *Geol. Rom.* 1: 33-131.

Ouadi, N. & Bonifay, M.F. 1998. Etudes Paléontologique et taphonomique de restes de proboscidiens. *Bull. Mus. Anthropol. Préhist. Monaco*, 39: 17-27.

Palombo, M.R. & Villa, P. (in press). Sexual dimorphic characters of *Elephas (Palaeoloxodon) antiquus* Falconer & Cautley, 1847 from "Grotte Santo Stefano" (Viterbo, Central Italy). *Deinsea*.

Paronuzzi, P. & Tonon, M. 1992. Il bacino lacustre villafranchiano di Steggio (Prealpi venete, Treviso): primi dati stratigrafici ed evidenze neotettoniche. *Il Quaternario* 5:251-268.

Reggiani, P. 1999. The elephant *Archidiskodon meridionalis* (Nesti, 1825) from the Lower Pleistocene of Steggio (Possagno, Treviso, north-east Italy). *Soc. Paleont. Ital.* 38 (1): 109-119.

Sala, B. & Barbi, G. 1996. Descrizione della fauna. In A. M. Radmilli & G. Boschian (eds.), *Gli scavi a Castel di Guido, il più antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano. Istituto Italiano di Preistoria e Protostoria:* 55-90. Firenze.

Tsoukala, E. & Lister, A. 1998. Remains of straight-tusked elephant, *Elephas (Palaeoloxodon) antiquus* Falc. & Caut. (1847) ESR-dated to oxygen isotope Stage 6 from Grevena (W. Macedonia, Greece). *Soc. Paleont. Ital.* 37 (1): 117-139.

A stylohyoideum of *Palaeoloxodon antiquus* from Gesher Benot Ya'aqov, Israel: morphology and functional inferences

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SUMMARY: Among the mammal remains discovered at Gesher Benot Ya'aqov (south of the Hula Valley, Dead Sea Rift, Israel) were cranium, tusk fragments, and limb bones that were assigned to an extinct straight-tusked elephant, *Palaeoloxodon antiquus*. One stylohyoideum was also collected. Based on inferences from data on living elephants, it is hypothesized that *P. antiquus* had a tongue about 80 cm long used to grasp leaves and grasses. Further, *P. antiquus* lived in small herds, about 5-15 individuals, and that herd members could have communicated with infrasonic calls with other herds, a few kilometers away. All in all, the hyoid apparatus has been a pivotal structure for adaptation in the course of proboscidean evolution.

Gesher Benot Ya'aqov (GBY), located south of the Hula Valley, Dead Sea Rift, a segment of the Great African Rift System, is known for its early to middle Pleistocene (780,000 years ago) sedimentary sequence comprised of several Acheulian archaeological horizons, rich in lithic assemblages as well as in fauna and flora (Goren-Inbar *et al.* 2000). Material referable to extinct straight-tusked elephant, *Palaeoloxodon antiquus* (family Elephantidae, order Proboscidea) includes a cranium, tusk fragments, limb bones, and one left stylohyoideum (Goren-Inbar *et al.* 1994). Some authors prefer to use *Elephas* (*Palaeoloxodon*) *antiquus* instead of *Palaeoloxodon antiquus*.

The stylohyoid (Hebrew University catalogue no. GBY #215) was found in sediments probably originating from Layer II-6 (Trench II, Area B), the same layer where the cranium material of *P. antiquus* was found. One of a set of little studied bones, the stylohyoid is found deep in the throat (the hyoid apparatus comprised of two stylohyoidea, two thyrohyoidea, and one basihyoideum) of elephants, living and extinct (Shoshani 1986). They are rarely collected from extant or extinct proboscideans. Unfamiliarity with these bones has resulted in describing a stylohyoid as an antler of an extinct deer (Green 1956). The stylohyoid is a Y-shaped bone, one "arm" of the Y is the superior ramus, the other "arm" is posterior ramus, and the third "arm" is the inferior ramus (terminology after Inuzuka *et al.* 1975). In this specimen, the inferior ramus is broken, otherwise it is in good condition; the combined superior-posterior length is 135 mm. This specimen does not have the typical "angulus" (a depression on the superior-posterior rami as observed in side view) that has been observed on several stylohyoid bones of *P. naumanni* (Inuzuka *et al.* 1975). This difference could be a species difference between *P. naumanni* and *P. antiquus*. GBY #215 has a tubercle on the superior ramus that may be homologous to tubercles observed on some *P. naumanni* stylohyoidea. It is noted that only one stylohyoid of *P. antiquus* was examined compared to several stylohyoids of *P. naumanni*.

Based on the work of Inuzuka (1977a, b) and our morphological observations (in the context of archeological settings of GBY, as well as other observations of skeletons of *P. naumanni*), it is suggested that the genus *Palaeoloxodon* be considered a *bona fide* taxon and not a subgenus of *Elephas*. Detailed long-term study (about 25 years) of processes and grooves for muscle attachment and twisting of bones on the hyoid apparatus (mostly stylohyoidea) enables the authors to infer functionality for these bones. Elephantid taxa, for example, possess a posterior ramus which is absent in some early proboscideans, e.g., *Mammut americanum* (Tassy & Shoshani 1988; Saegusa & Shoshani 1992). This ramus serves for attachment of the digastricus muscle that helps to open the jaw (Eales 1926; Garrod 1875; Gasc 1967). Identification of GBY 215 was made by comparing it to 194 stylohyoid hyoid elements, representing 151 individuals of living and extinct proboscideans, namely: Mammoths (e.g., *Mammuthus primigenius*), Asian elephants (*Elephas maximus*), extinct elephantids (e.g., *E. recki*, *Palaeoloxodon naumanni*), African elephants (*Loxodonta cyclotis* and *L. africana*), stegodons (e.g., *Stegodon aurorae*), gomphotheres (e.g., *Gomphotherium productum, Amebelodon floridanus*), mammutids (*Mammut americanum*), and a deinothere (*Deinotherium giganteum*). Based on gular musculature of living elephants and morphology of hyoid apparatus (e.g., Eales 1926), it is hypothesized that the functional anatomy of hyoid of *P. antiquus* was similar to that of extant elephants. It is suggested that *P. antiquus* had a tongue about 80 cm long that could be projected a short distance from the mouth to grasp leaves and grasses. The tongue along with a flexible trunk, enabled straight-tusked elephants to graze or to browse on Pleistocene foliage about 8 meters above ground [trunk flexibility is deduced from size and position of external naris and from size and numbers of infraorbital canals (Shoshani 1986); height above ground is estimated from data on living elephants when standing on hind legs (Shoshani *et al.* 1987). It is suggested that *P. antiquus* lived in small herds, about 5-15 individuals, and that herd members could have communicated with infrasonic calls with other herds, perhaps a few kilometers away (communication hypothesis is based on hyoid and cochlear anatomy; Meng *et al.* 1997). In addition, it is proposed that the hyoid apparatus supported a pharyngeal pouch used as a resonating chamber (similar to the condition in howler monkey; Vaughan *et al.* 2000). At other periods, this pouch was used to store water for drinking or dousing in time of stress (Shoshani 1998). It appears that the hyoid apparatus has been a pivotal structure for adaptation to newly available ecological niches of in their long geological history.

REFERENCES

Eales, N.B. 1926. The anatomy of the head of a foetal African elephant, *Elephas africanus (Loxodonta africana)*. Part I. *Transactions of the Royal Society of Edinburgh* 54(3): 491-551 + 12 plates.

Garrod, A.H. 1875. On the hyoid bone of the elephant. *Proceedings of the Zoological Society of London* 1875: 365-367.

Gasc, J.-P. 1967. Squelette hyobranchial. In P.-P. Grasse (ed.), *Traité de Zoologie* 16(1): 550-583, 1103-1106. Paris: Masson et Cie Editeurs.

Goren-Inbar, N., Lister, A., Werker, E. & Chech, M.A. 1994. A butchered elephant skull and associated artifacts from the Acheulian site of Gesher Benot Ya'aqov, Israel. *Paleorient* 20/1: 99-112.

Goren-Inbar, N., Feibel, C.S., Verosub, K.L., Melamed, Y., Kislev, M.E., Tchernov, E., & Saragusti, I. 2000. Pleistocene Milestones on the Out-of-Africa Corridor at Gesher Benot Ya,aqov, Israel. *Science* 289: 944-974.

Green, M. 1956. The lower Pliocene Ogallala-Wolf Creek vertebrate fauna, South Dakota. *Journal of Paleontology* 30(1): 146-169.

Inuzuka, N. 1977a. On a fossil skull of Palaeoloxodon naumanni from saruyama, Shimosa-machi, Chiba Prefecture, central Japan. *Journal of the Geological Society*

Japan 83: 523-536.

Inuzuka, N. 1977b. On the origin of *Palaeoloxodon naumanni* - A comparative osteology of the cranium. *Journal of the Geological Society Japan* 83: 639-655.

Inuzuka, N., Hasegawa, Y., Nogariya, H., & Kamei, T. 1975. On the stylohyoid bone of Naumann's elephant (*Elephas naumanni* Makiyama) from Lake Nojiri. Memoirs Faculty of Science, Kyoto University, *Series of Geology and Mineralogy* 41(1): 49-65.

Meng, J., Shoshani, J. & Ketten, D. 1997. Evolutionary evidence for infrasonic sound and hearing in proboscideans. *Journal of Vertebrate Paleontology*, 17: 64A.

Saegusa, H. & Shoshani, J. 1992. A stylohyoideum of *Stegodon* (Proboscidea, Stegodontidae) from the Pleistocene of Java and its phylogenetic significance. *Journal of Vertebrate Paleontology* 12,: 50A.

Shoshani, J. 1986. *On the phylogenetic relationships among Paenungulata and within Elephantidae as demonstrated by molecular and osteological evidence*. Ph.D. Dissertation, Wayne State University, Detroit (Michigan). Ann Arbor, Michigan University Microfilms, 649 pp.

Shoshani, J. 1998. Understanding proboscidean evolution: a formidable task. *Trends in Ecology & Evolution* 13(12): 480-487.

Shoshani, J., Hillman, J.C. & Walcek, J.M. 1987. "Ahmed", the logo of the Elephant Interest Group: encounters in Marsabit and notes on his model and skeleton. *Elephant* 2(3): 7-32.

Tassy, P. & Shoshani, J. 1988. The Tethytheria: elephants and their relatives. In M. Benton (ed.), *The phylogeny and classification of the tetrapods. 2: Mammals* (The Systematics Association, Special 35B): 283-315. Oxford: Clarendon Press.

Vaughan, T.A., Ryan, J.M. & Czaplewski, N.J. 2000. *Mammalogy* (4th edition, Fort Worth (Texas): Saunders College Publishing, Harcourt Brace Jovanovich Publishers.

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Hyoid apparatus: a little known complex of bones and its "contribution" to proboscidean evolution

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SUMMARY: The hyoid apparatus of extant and extinct proboscidean taxa is composed of five bones found deep in the throat – a pair of stylohyoidea, a pair of thyrohyoidea, and unpaired basihyoideum. These are little known and seldom collected. Functions associated with this apparatus include feeding, sound production (including infrasonic calls), and water storage in the pharyngeal pouch used to spray themselves when excessive heat prevails and there is no water source nearby. These functions are believed to have co-evolved in late Oligocene to early Miocene periods, about 25 million years ago. Results from cladistic analyses of hyoidean characters comprise these relationships: *(Mammut (Gomphotherium (Stegodon (Loxodonta (Elephas, Palaeoloxodon, Mammuthus).*

1. INTRODUCTION

When the senior author began his study on hyoids of elephants (about 25 years ago) there was little information concerning the hyoid apparatus of proboscideans. A few museums possess these delicate small bones. In paleontological excavations, one often finds portions of a stylohyoid, thyrohyoid or basihyoid. Even hyoid bones of living elephants are often not recognized or are damaged during dissection (cf. Fig. 1). Broken hyoid elements are confused with rib fragments, and one frequently finds them among scraps in neontological or paleontological museum collections. It soon became evident that hyoid bones of proboscideans are rare finds. Shoshani's interest in the hyoid apparatus grew when he learned that in one paper (Green 1956) a stylohyoid which appeared to have been associated with remains of *Amebelodon* (a gomphothere, order Proboscidea; M. Skinner, pers. comm. by way of M. C. McKenna) was described as an antler of an extinct deer, *Meryceros major*, family Antilocapridae, order Artiodactyla. This is an example of unfamiliarity with these bones and it inspired the launching of a long-term study of the hyoids of proboscideans. In addition, knowledge of the hyoid apparatus of living elephants may help us to better understand fossil taxa and vice versa.

Thus, the objectives of this study have been to systematically study any hyoid bones of proboscideans, photograph and/or draw them, note their positions in the gular region, describe them, their functions, and record any phylogenetic changes among taxa. During the years, we also have provided an overall assessment of the importance of these bones in term of their physiology and evolution.

2. MATERIALS AND METHODS

Details on the osteological material studied are given below. Bones were photographed and drawn in lateral and medial views and cross sections were made. Measurements and other morphological characters were entered into data sheets. A total of 38 characters has been evaluated, of which 20 may be useful in phylogenetic and functional analyses (e.g. Shoshani 1986; Shoshani, 1996; Tassy & Shoshani 1988).

2.1 Stylohyoidea

Material of hyoid apparati of living and extinct proboscideans studied, amount to 194 stylohyoid elements representing 151 individuals: 81 elephantids, 7 stegodontids, 40 gomphotheriids, 22 American mastodons, and 1 deinothere. The breakdown is: 81 elephantids, with at least eleven taxa, e.g. *Loxodonta cyclotis, L. africana, Elephas maximus, E. recki, Palaeoloxodon antiquus*, and *Mammuthus primigenius* [112 bones, 31 pairs, 37 odd bones (19 left, 18 right), 13 unknown; 8 males, 20 females, 53 of unknown sex], 7 stegodontids, with at least four taxa, e.g. *Stegodon aurorae* [7 bones, 0 pairs, 7 odd bones (4 left, 3 right); no sex was assigned], 40 gomphotheriids, with at least four taxa, e.g. *Gomphotherium productum* and *Amebelodon floridanus* [43 bones, 3 pairs, 34 odd bones (20 left, 14 right), 3 unknown; no sex was assigned], 22 American mastodons, *Mammut americanum* [31 bones, 6 pairs, 16 odd bones (10 left, 6 right), 3 unknown; 4 males, 2 females, 16 of unknown sex], and 1 deinothere (*Deinotherium giganteum*).

2.2 Thyrohyoidea

A total of 33 thyrohyoidea was examined, representing 22 individuals. These include: 9 elephantids, 1 stegodontid, 1 gomphotheriid, and 11 American mastodons. The breakdown is: 9 elephantids, that is, *Loxodonta africana, Elephas maximus*, and *Mammuthus primigenius* [17 bones; 8 pairs, 1 odd bone, laterality unknown; unknown sexes], 1 stegodontid, that is, *Stegodon zydanskyi* [2 bones; 1 pair, unknown sex], 1 gomphotheriid, that is, *Amebelodon floridanus* [1 bone, laterality and sex unknown], 11 American mastodons, *Mammut americanum* [13 bones; 2 pairs, 6 odd bones (5 left, 1 right), 3 odd laterality unknown; sexes unknown for all].

2.3 Basihyoidea

A total of 21 basihyoidea of proboscideans was examined (12 elephantids, 1 stegodon, 2 gomphotheriids, and 6 mammutid). No breakdown is given since the basihyoid is an odd bone in adult animals. Of these 21 bones, the sex of only 3 proboscideans is known; all are females Asian elephants, *Elephas maximus*.

2.4 Soft tissue

Dissections of gular musculature have been essential for learning about origin and insertion of muscles and to evaluate function in extinct species. We dissected and obtained data from nine specimens of *Loxodonta africana* (n=3) and *Elephas maximus* (n=6). Detailed notes, photographs and drawings of muscles were made with reference to published records (e.g. Eales, 1926).

3. Results and discussion

Mammals in general have a hyoid apparatus comprised of nine bones (single basihyal, and paired thyrohyals, ceratohyals, epihyals, and stylohyals). These articulate in a box-like fashion and attach via the tympanohyal cartilages to the basicranium deep in the throat (Fig. 1). Occasionally, the tympanohyals ossify, and the hyoid complex thus comprises of 11 bones (Gasc 1967; Walker and Homberger 1992, personal observations). In extinct and living proboscideans, the ceratohyals and epihyals were lost, creating a gap between the stylohyals and the basihyal-thyrohyal complex (these three bones are often fused and appear as an upside down English letter “U”). Having lost the connection with the epihyals and ceratohyals, the basihyal and the thyrohyals unit descended downwards away from the cranium similar to the situation found in humans (Gray 1901). In a typical mammal, the stylohyals, or stylohyoidea, are straight rod-like bones. In human, the stylohyals are fused to the basicranium; they are longer in males than in females (Gray 1901). In early proboscideans (e.g. *Mammut americanum*), this bone is also simple, but

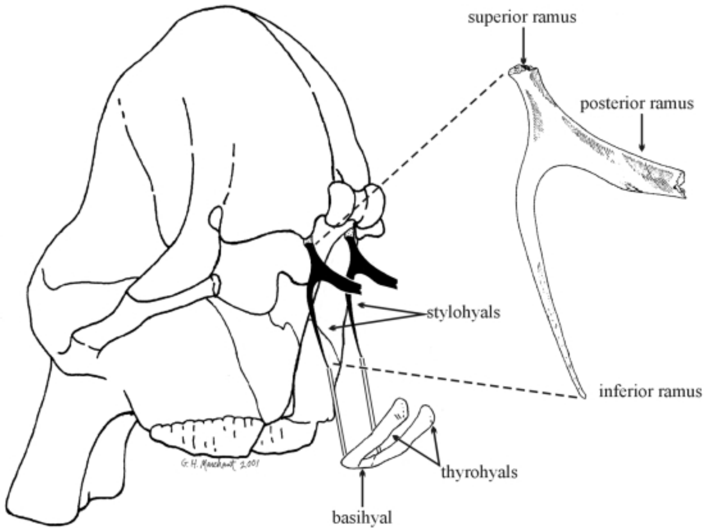

Fig.1 - Cranium of an Asian elephant (*Elephas maximus*) with hyoid bones in place, and labeled stylohyoideum (modified after Inuzuka *et al.* 1975).

often with development of an incipient additional projection. In advanced proboscideans, e.g. gomphotheres and elephantids, an additional process ("arm") has developed, rendering the bone to look like the English letter "Y". One "arm" of the "Y" is the superior ramus, the other "arm" is posterior ramus, and the third "arm" is the inferior ramus (Fig. 1; terminology after Inuzuka *et al.* 1975). Superior and inferior rami are the original (primitive) structures; the posterior ramus is a new development within Proboscidea. In elephantid taxa, the posterior ramus serves for attachment of the digastricus muscle that (together with the lateral pterygoid muscle) helps to open the jaw (Garrod 1875; Gasc 1967). In living elephants these paired muscles attach on the hyoid apparatus to make up the muscular tongue: styloglossus (from stylohyoidea), hyoglossus lateralis (from thyrohyoidea), hyoglossus anterior (from basihyoideum), and geniohyoglossus (from mandibular symphysis and basihyoideum). Functions of these muscles are (after Watson 1874; Eales, 1926; Tortora & Anagnostakos 1975): styloglossus – elevates tongue and draws it backwards (retraction); hyoglossus lateralis and hyoglossus anterior – draw tongue sideways, and help in depression and retraction; geniohyoglossus – depresses and thrusts tongue forward (protraction). These muscles and their relationships to other gular muscles are depicted in figures 2 and 3.

4. EVOLUTIONARY TRENDS OBSERVED

4.1 Basihyoidea

Through time, these bones have become thinner and straighter, and have lost the geniohyoideus ridge. American mastodons and gomphotheres have basihyoidea that are round in cross section; those of stegodontids and elephantids are flattened. Early proboscideans have arched basihyoidea on anterior and posterior sides; those of advanced taxa are straight at front and arched at back. *M. americanum* and gomphotheres possess the geniohyoideus ridge (for attachment of geniohyoideus muscle) on the ventral side of the basihyoideum; all elephantids examined lack this ridge.

4.2 Thyrohyoidea

Through time, these bones have become less

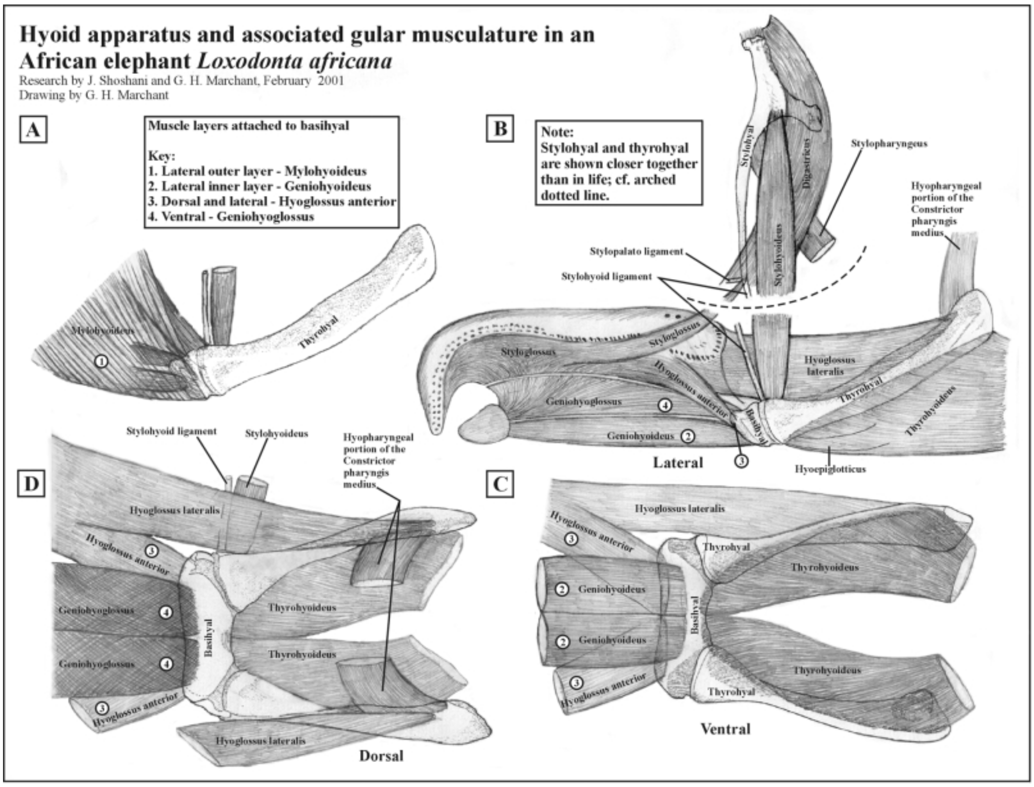

Fig.2 - Simplified drawings of the hyoid apparatus and associated gular musculature in an African elephant, *Loxodonta africana* (artwork by G.H. Marchant).

robust, more twisted. Examples: American mastodons and gomphotheres have thyrohyoidea that are robust and slightly twisted; in advanced taxa the thyrohyoidea are more delicate and more twisted. In dorsal view, the posterior part of the left thyrohyoideum twists clockwise, and the right thyrohyoideum twists in counterclockwise direction.

4.3 Stylohyoidea

Through time, a new (inferior) ramus have been added, the bones have become thinner, and the inferior ramus has become more twisted and deflected laterally. In addition, there is a change in the ratio of the superior to posterior rami. In American mastodons (*M. americanum*) only the superior and inferior rami are present. Often, a “bud” is present in the place where the posterior ramus develops in advanced proboscideans (gomphotheriids, stegodontids, and elephantids). Early proboscideans have stylohyoidea that are round in cross section; those of elephantids are flattened and more delicate. Primitive proboscideans have inferior rami that have little of no twisting; those of elephantids are twisted. In posterior view, the left stylohyoideum twists clockwise, and the right thyrohyoideum twists in counterclockwise direction. Viewed anteriorly, in the American mastodon, the inferior ramus is about in the line of the combined superior-posterior rami; in gomphotheres and elephantids the inferior ramus becomes deflected laterally. On average, in *M. americanum* the absolute length of the stylohyoideum (combined length of superior-inferior rami) is the largest among the proboscideans examined thus far. In gomphotheres, stegodontids and loxodontines, the ratio of the superior to posterior rami is about 1:1. In many ele-

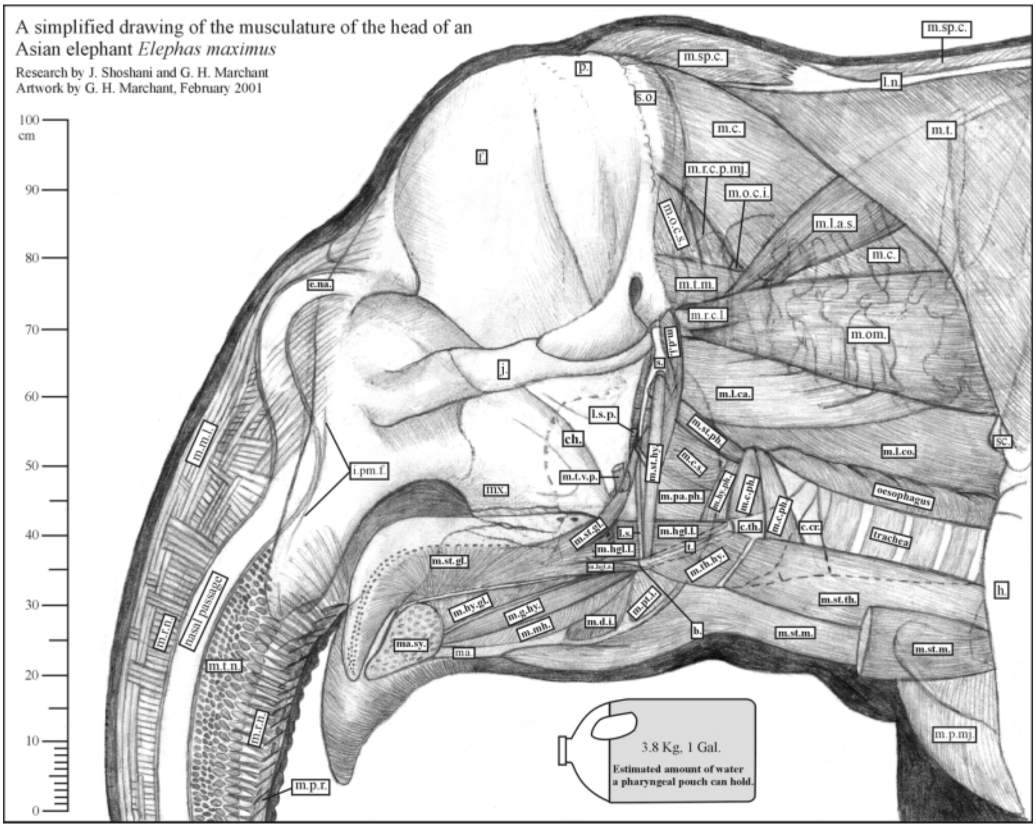

Fig.3 - A simplified drawing of the musculature of the head of an Asian elephant, *Elephas maximus*, with key for bones, cartilages, and muscles (artwork by G.H. Marchant).

Bones, muscles, and cartilages key:

Bones:

Basihyal - b.
Choana - ch.
External naris - e.na.
Frontal - f.
Humerus - h.
Jugal - j.
Inter-premaxillary fossa - i.pm.f.
Mandible - ma.
Mandibular symphysis - ma.sy.
Maxilla - mx.
Parietal - p.
Scapula - sc.
Stylohyal - s.
Supra-occipital - s.o.
Thyrohyal - t.

Cartilages:

Cricoid cartilage - c.cr.
Thyroid cartilage - c.th.

Muscles:

Head and Neck

Complexus (Semispinalis capitis) - m.c.
Levator anguli scapulae - m.l.a.s.
Ligamentum nuchae - l.n.
Longus capitis - m.l.ca.
Longus coli - m.l.co.
Obliquus capitis superioris - m.o.c.s.
Obliquus capitis inferioris - m.o.c.i.
Omotrachelian - m.om.
Pectoralis major - m.p.mj.
Pteryogoideus internus - m.pt.i.
Rectus capitis lateralis - m.r.c.l.
Rectus capitis posticus major - m.r.c.p.mj.
Splenius capitis - m.sp.c.
Sterno-mandibularis - m.st.m.
Tensor veli palatini - m.t.v.p.
Trachelo-mastoideus - m.t.m.
Trapezius - m.t.

Hyoid and gular

Constrictor pharyngis - m.c.ph.
Constrictor superioris - m.c.s.
Digastricus - m.d.i.
Genio-hyoglossus - m.hy.gl.
Genio-hyoideus - m.g.hy.
Hyoglossus anterior - m.hgl.a.
Hyoglossus lateralis - m.hgl.l.
Hyopharyngeus - m.hy.ph.
Mylohyoideus - m.mh.
Palato-pharyngeus - m.pa.ph.
Sterno-thyroideus - m.st.th.
Styloglossus - m.st.gl.
Stylohyal ligament - l.s.
Stylohyoideus - m.st.hy.
Stylopalato ligament - l.sp.
Stylopharyngis - m.st.ph.
Thyrohyoideus - m.th.hy.

Trunk

Maxillo labialis (Levator proboscidis) - m.m.l.
Pars rimana (Depressor proboscidis) - m.p.r.
Rectus nasi - m.r.n.
Transverse nasi - m.t.n

phantine specimens (genera *Elephas* and *Mammuthus*), data indicate a shift towards a 1:3 ratio – that is, the superior ramus decreases in length, while the posterior increases.

5. Phylogenetic results

Inuzuka (1977a, b) considered *Palaeoloxodon* to be distinct from *Elephas*. Inuzuka's (1977a, b) work, our morphological observations, as well as studies of skeletons of *P. naumanni*, have convinced us that the genus *Palaeoloxodon* be considered a *bona fide* taxon and not a subgenus of *Elephas*. Based on results from cladistic analysis (except for results of *Deinotherium*, to be presented elsewhere), of the taxa examined, genera that appear successively on the cladogram, from the most primitive (bottom of cladogram, Fig. 4) to most advanced are: *Mammut, Gomphotherium, Stegodon, Loxodonta, Palaeoloxodon/Elephas* and *Mammuthus*. These findings corroborate other morphological results (Maglio 1973; Coppens *et al.* 1978; Shoshani & Tassy 1996). Hyoidean synapomorphies in support of these relationships were provided by Shoshani (1986); Tassy and Shoshani (1988), and results obtained in this study. All taxa studied except Mammut, that is, members of the clade Elephantida of Shoshani *et al.*, 1998 [comprising of "*(Gomphotherium (Stegodon (Loxodonta (Elephas, Palaeoloxodon, Mammuthus)*"] possess the posterior ramus. In addition, the inferior ramus of the stylohyoid of non-mammutid taxa is deflected laterally. Members in the clade "*(Stegodon (Loxodonta (Elephas, Palaeoloxodon, Mammuthus)*" have oval or flattened (non-round) stylohyoid and basihyoid bones in cross sections, have more delicate and more twisted thyrohyoidea, and also have lost the 'shelf' observed in gomphotheres. The four elephantids, "*(Loxodonta (Elephas, Palaeoloxodon, Mammuthus)*", have much twisted thyrohyoid bones (not known in Palaeoloxodon), and possess at least one 'bend' on the inferior ramus. Finally "*(Elephas* and *Mammuthus)*" have thin stylohyoidea bone in cross section and short superior ramus.

6. Function and Adaptation

Based on gular musculature of living elephants (e.g. Eales 1926) and morphology of hyoid apparatus, it is hypothesized that extinct American mastodons had similar functional anatomy of the hyoid to those of extant elephants. Thus, it is suggested that *M. americanum* had a 70-90 cm long tongue that could be protruded a short distance from the mouth to grasp leaves and grasses. Together with a flexible trunk, these mastodons could browse on Pleistocene foliage about 7-9 meters above ground [trunk flexibility is deduced from size and position of external naris and from size and numbers of infraorbital canals (many *M. americanum* specimens have two instead of one canal as observed in living elephants; Shoshani, 1986); height above ground is estimated from data on living elephants when standing on hind legs; Shoshani *et al.* 1987]. It is also suggested that *M. americanum* lived in small herds, about 10-15 individuals, and that herd members could have communicated with infrasonic calls with other herds, perhaps a few kilometers away (communication hypothesis is based on hyoid and cochlear anatomy; Meng *et al.* 1997). Further, it is suggested that the hyoid apparatus supported a pouch, and when empty, was used as a resonating chamber (similar to what was observed in howler monkey; Vaughan *et al.* 2000); at other times it was used to store water for drinking or dousing in time of stress (Shoshani 1998). All in all, detailed study of processes and grooves for muscle attachment and twisting of bones on the hyoid apparatus (mostly stylohyoidea) enables us to infer functionality for little known bones. Despite its small size, the hyoid apparatus appears to have been a pivotal structure for adaptation to newly available niches for survival of proboscideans.

7. Concluding remarks

The objectives of this study as outlined above were accomplished. We learned that knowledge of the hyoid apparatus from living elephants has helped us better understand fossil taxa and

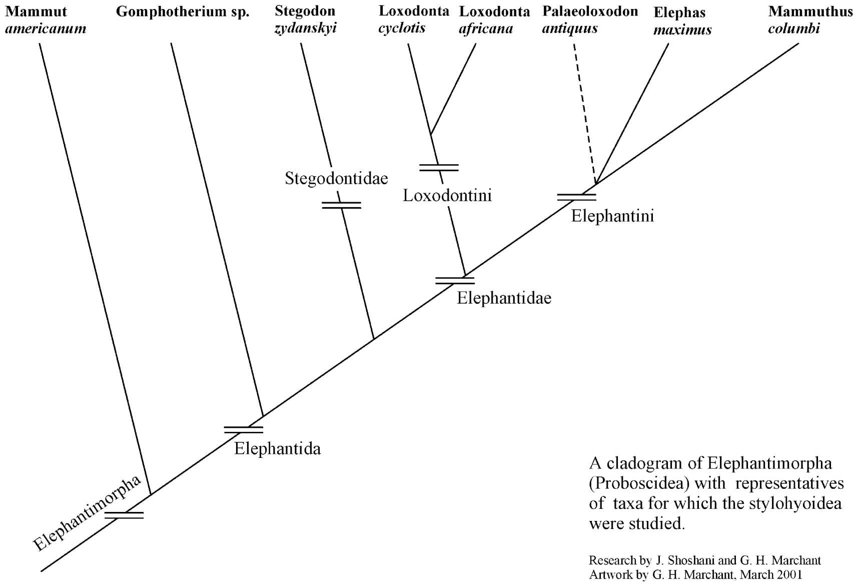

Fig.4 - A cladogram of proboscidean taxa (classified in Elephantimorpha) depicting representatives for which the stylohyoidea were studied (artwork by G.H. Marchant).

vice versa. Characters (and by inference functions), we also learned, appeared to have co-evolved in late Oligocene to early Miocene periods, about 25 million years ago. The small subset of characters on the stylohyoidea of Proboscidea can be used as an example of independent evidence for the relationships among Elephantidae genera. When morphological characters were analyzed cladistically they resulted in the relationships depicted in figure 4. These results are congruent with dental-based (e.g. Coppens *et al.* 1978) and non-dental hypotheses (this study). It appears that the stylohyoideum co-evolved in parallel with dental features.

7. References

Coppens, Y., Maglio, V.J., Madden, C.T., and Beden, M. 1978. Proboscidea. In V. J. Maglio and H.B.S. Cooke (eds.), *Evolution of African mammals*: 336-367. Cambridge (Massachusetts): Harvard University Press.

Eales, N.B. 1926. The anatomy of the head of a foetal African elephant, *Elephas africanus* (*Loxodonta africana*). Part I. *Transactions of the Royal Society of Edinburgh* 54(3): 491-551.

Garrod, A.H. 1875. On the hyoid bone of the elephant. *Proceedings of the Zoological Society of London* 1875: 365-367.

Gasc, J.-P. 1967. Squelette hyobranchial. In P.~-P. Grasse (ed.), *Traité de Zoologie* 16(1): 550-583, 1103-1106. Paris: Masson et Cie Editeurs.

Gray, H. 1901. *Gray's Anatomy, descriptive and surgical.* (1974 printing edited by T. P. Pick and R. Howden). Philadelphia: Running Press.

Green, M. 1956. The lower Pliocene Ogallala-Wolf Creek vertebrate fauna, South Dakota. *Journal of Paleontology* 30(1): 146-169.

Inuzuka, N. 1977a. On a fossil skull of Palaeoloxodon naumanni from saruyama, Shimosa-machi, Chiba Prefecture, central Japan. *Journal of the Geological Society Japan* 83: 523-536.

Inuzuka, N. 1977b. On the origin of Palaeoloxodon naumanni -A comparative osteology of the cranium. *Journal of the Geological Society Japan* 83: 639-655.

Inuzuka, N., Hasegawa, Y., Nogariya, H. & Kamei, T. 1975. On the stylohyoid bone of Naumann's elephant (*Elephas naumanni* Makiyama) from Lake Nojiri. Memoirs Faculty of Science, Kyoto University, *Series of Geology and Mineralogy* 41(1): 49-65.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Transactions of The American Philosophical Society of Philadelphia, New Series* 63(3): 1-149.

Meng, J., Shoshani, J. & Ketten, D. 1997. Evolutionary evidence for infrasonic sound and hearing in proboscideans. *Journal of Vertebrate Paleontology*, 17: 64A.

Shoshani, J. & Tassy, P. (eds). 1996. *The Proboscidea: evolution and palaeoecology of elephants and their relatives*. Oxford: Oxford University Press.

Shoshani, J. 1986. *On the phylogenetic relationships among Paenungulata and within Elephantidae as demonstrated by molecular and osteological evidence*. Ph.D. Dissertation, Wayne State University, Detroit (Michigan). Ann Arbor, Michigan University Microfilms, 649 pp.

Shoshani, J. 1996. Para- or monophyly of the gomphotheres and their position within Proboscidea. In J. Shoshani and P. Tassy (eds.), *The Proboscidea: evolution and palaeoecology of elephants and their relatives*: 149-177. Oxford: Oxford University Press.

Shoshani, J. 1998. Understanding proboscidean evolution: a formidable task. *Trends in Ecology & Evolution* 13(12): 480-487.

Shoshani, J., Golenberg, E.M. & Yang, H. 1998. Elephantidae phylogeny: morphological versus molecular results. *Acta Theriologica*, 5: 89-122.

Shoshani, J., Hillman, J.C. & Walcek, J.M. 1987. "Ahmed", the logo of the Elephant Interest Group: encounters in Marsabit and notes on his model and skeleton. *Elephant* 2(3): 7-32.

Tassy, P. & Shoshani, J. 1988. The Tethytheria: elephants and their relatives. In M. Benton (ed.): *The phylogeny and classification of the tetrapods. Volume 2: Mammals* 283-315. Oxford: Clarendon Press.

Tortora, G.J. & Anagnostakos, N.P. 1975. *Principles of anatomy and physiology*. San Francisco: Canfield Press.

Vaughan, T.A., Ryan, J.M. & Czaplewski, N.J. 2000. *Mammalogy* (4th edition, Fort Worth (Texas): Saunders College Publishing, Harcourt Brace Jovanovich Publishers.

Walker, W.F. & Homberger, D.G. 1992. *Vertebrate dissection* (8th edn). Fort Worth (Texas): Harcourt Brace Jovanovich College Publishers.

Watson, M. 1874. Contributions to the anatomy of the Indian Elephant (*Elephas Indicus*). Part III The Head. *Journal of Anatomy and Physiology* 8: 85-94.

The World of Elephants - International Congress, Rome 2001

Elephants and other Proboscideans: a summary of recent findings and new taxonomic suggestions

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SUMMARY: Today we recognize 165 species and subspecies of proboscideans, classified in 42 genera and 8 families. Of these, three species are extant: the forest African elephant (*Loxodonta cyclotis*), bush African elephant (*L. africana*), and the Asian elephant (*Elephas maximus*, with three subspecies). In 2000, the estimated world population of elephants was just over one half million; most are African elephants. New taxa include Mammutida and Elephantida, and one proposed here: Plesielephantiformes, as a sister taxon to Elephantiformes. Neontological research is currently under way on these areas of investigation: anatomy and physiology on eye, trunk, hyoid apparatus, brain, hearing, reproduction, ecology, behavior, and conservation. Topics for future research include: phylogenetic positions of Anthracobunids, *Moeritherium*, tetralophodont gomphotheres, *Stegolophodon* and *Stegodon*, and intra-familial relationships among *Loxodonta, Elephas* and *Mammuthus*, and also continuing studies on brain, reproductive biology, and conservation, emphasizing educational approaches.

1. INTRODUCTION

Henry Fairfield Osborn published his monumental two-volume *Proboscidea* in 1936 and 1942 (Osborn 1936, 1942). In 1996 the first and third authors of this contribution edited another volume by the same name that reviewed advances in our knowledge since Osborn (Shoshani & Tassy 1996). In this presentation, we build on the 1996 volume to summarize recent findings on living and extinct proboscideans and propose some taxonomic revisions and additions.

In 1942, following Osborn, 352 species and subspecies of proboscideans were recognized; they were classified in 40 genera, and 8 families. In 1996, corresponding numbers were 162, 40, and 8 (not the same genera and families). Most recently a new genus and three new species have been described: *Phosphatherium escuilliei* (by Gheerbrant, Sudre & Cappetta 1996) from Morocco, *Stegodon sondaari* (by Van den Bergh 1997) from Indonesia named in honor of Paul Y. Sondaar [Note: Van den Bergh placed *Stegodon* in the family Elephantidae, *contra* other investigators who place *Stegodon* in the family Stegodontidae (more below)], and *Zygolophodon aegyptensis* (by Sanders and Miller, in press) from Egypt. In addition, *Loxodonta cyclotis* (Matschie 1900), was elevated from subspecies to species level (Grubb *et al*. 2000). Results from Molecular findings (cytochrome b), however, indicate that of the one dozen of sequences of *L. cyclotis* not all samples clustered to form a clade (there were two exceptions: two savanna elephants had forest haplotype!) (Debruyne in preparation). Based on the work of Inuzuka (1977a, b) and our morphological observations, as well as studies of skeletons of *P. naumanni*, we suggest that *Palaeoloxodon* is a *bona fide* genus, instead of a subgenus of *Elephas*.

These descriptions and a revision bring the total of living and extinct proboscideans to 165 species (classified in 42 genera, and 8 families). Of these three species, two are monotypic and one is with three subspecies are alive today: the forest African elephant (*L. cyclotis*), the bush African elephant (*L. africana*), and the Asian elephant (*E. maximus*). The Asian elephant is believed to include three subspecies (Shoshani & Eisenberg 1982): the Sumatran Asian elephant (*E. m. sumatranus*), the mainland Asian elephant (*E. m. indicus*), and the Sri Lankan Asian elephant (*E. m. maximus*) [sequence of listing represents an evolutionary trend, Shoshani 2000].

As of the year 2000, the average estimated population of elephants in the world was just over half a million (minimum 329,663, maximum 706,090). Of these, there are 278,205 – 637,599 African elephants of both species in the wild (Marchant *et al.* 2000) and 748-808 in captivity (Shoshani, S.L. 2000), and 36,450-50,250 Asian elephants in the wild (Sukumar & Santiapillai 2000) and 14,260-17,433 in captivity (Shoshani, S.L. 2000).

2. Paleontology, including Taxonomy

The classification of the 165 proboscidean taxa into 42 genera and 8 families is slightly different from the 1996 publication. Subfamilies and tribes and higher categories were added to elucidate cladistic findings. In addition, we now include *Choerolophodon* (subfamily Choerolophodontinae) in the family Gomphotheriidae (*contra* Tassy 1985). New taxa include Mammutida and Elephantida (Shoshani *et al.* 1998), and one we propose here, Plesielephantiformes as a sister taxon to Elephantiformes [Plesielephantiformes includes: Numidotheriidae, Barytheriidae, and Deinotheriidae; Elephantiformes includes: Palaeomastodontidae Phiomiidae, Mammutidae, Gomphotheriidae, tetralophodont gomphotheres, Stegodontidae, and Elephantidae]. The suggested synapomorphy for Plesielephantiformes is bilophodonty. Problem may arise since it is possible that the lophodonty of deinotheres, for example, may not be homologous with lophodonty of *Phosphatherium* and numidotheres. Other hypotheses to be tested include whether *Palaeomastodon* is a/the common ancestor of Mammutida (or a sister-taxon to it), and also whether *Phiomia* is a/the common ancestor of Elephantida (or a sister-taxon to it). Presentations during this ITC-8 meeting (Sun City South Africa) and those to be presented in Rome (Italy) will include these topics: new finding of proboscidean remains in Ethiopia, Eritrea; Schreger pattern on tusks; frozen mammoths (finding of the Jarkov mammoth); relationships within the family Elephantidae, and subjects on anatomy, physiology, ecology, and conservation.

3. Neontology

3.1 Topics investigated

Current investigations are being carried out on the eye (do elephants see colors?); on trunk anatomy and physiology (ongoing research; recently a team of investigators from Kansas State University has been investigating the proboscis from a respiratory perspective); on the hyoid apparatus (anatomy and physiology; two papers are published in this volume, i.e. Shoshani *et al.* 2001; Shoshani & Marchant 2001), summarizing its functions as tongue support, resonating chamber, and for water storage); and on the brain (gross anatomy and histological investigations one paper has been presented at the 8th Theriological Congress, Sun City, South Africa, and one again is in this volume, i.e. Kupsky *et al.* 2001). In addition, research is being conducted on reproduction in the wild and in captivity (immunological techniques to prevent pregnancy, and artificial insemination), on behavior (infrasonic communication aspects investigated in the field and laboratory observations, e.g. Meng *et al.* 1997). Other topics include Thailand elephants "play music" in an orchestra, and adult elephants "mentor" young unrelated elephants.

3.2 Conservation

After the 2000 CITES (Convention on International Trade in Endangered Species of Wild

Fauna and Flora) meeting in Nairobi, South Africa's elephant population was transferred to Appendix II but no further permission was granted to any party to export ivory for commercial purposes. All other African populations are listed in Appendix I CITES. *Elephas maximus* is placed in Appendix I of CITES.

4. FUTURE RESEARCH

Future research topics might include whether anthracobunids should be included in the Proboscidea or as a sister group in the Tethytheria, whether *Moeritherium* should be placed in Plesielephantiformes (a new taxon proposed here), or as an earlier offshoot of Proboscidea, what is the taxonomic position tetralophodont gomphotheres (i.e. those with four ridges on 4th premolars, the 1st and 2nd molars), should *Stegolophodon* and *Stegodon* be placed in the family Stegodontidae or in the family Elephantidae, and what are the intra-familial relationships among *Loxodonta, Elephas* and *Mammuthus* — is it (*Loxodonta* (*Mammuthus* + *Elephas*)) as suggested by the classical morphological data (e.g. Maglio 1973), or (*Elephas* (*Mammuthus* + *Loxodonta*)) based on some molecular data (Debruyne, in preparation)? In addition, it is suggested that studies should be continued on the form and function of the brain, and to find effective method for birth control in the wild, and on ways to reduce culling operations. In the field of conservation, we suggest that educational approaches to co-existence of humans and wildlife should be emphasized, especially as the larger animals are ecological keystone, or superkeystone species. Some of these ideas were discussed in Shoshani and Tassy (1996), and other in Shoshani (2000).

5. REFERENCES

Bergh,van den, G.D. 1997. *The late Neogene elephantoid-bearing faunas of Indonesia and their paleozoogeographic implications: a study of the terrestrial faunal successions of Sulawesi, Flores and Java, including evidence for early hominid dispersal east of Wallace's Line.* PhD Dissertation, Utrecht University, 364 p..

Debruyne, M.R. In preparation. *Molecular Phylogeny of the Elephantidae: how far do the mitochondrial studies conflict.*

Gheerbrant, E., Sudre, J. & Cappetta, H. 1996. A Palaeocene proboscidean from Morocco. *Nature* 383(6595): 68-70.

Grubb, P., Groves, C.P., Dudley, J.P. & Shoshani, J. 2000. Living African elephants belong to two species: *Loxodonta africana* (Blumenbach, 1797) and *Loxodonta cyclotis* (Matschie, 1900). *Elephant* 2(4): 1-4.

Inuzuka, N. 1977a. On a fossil skull of *Palaeoloxodon naumanni* from saruyama, Shimosa-machi, Chiba Prefecture, central Japan. *Journal of the Geological Society Japan* 83: 523-536.

Inuzuka, N. 1977b. On the origin of *Palaeoloxodon naumanni* - A comparative osteology of the cranium. *Journal of the Geological Society Japan* 83: 639-655.

Kupsky, W.J., Marchant, G.H., Cook, K. & Shoshani, J. 2001 Morphologic analysis of the hippocampal formation in *Elephas maximus* and *Loxodonta africana* with comparison to that of human. *This volume.*

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Transactions of The American Philosophical Society of Philadelphia, New Series* 63(3): 1-149.

Marchant, G.H., Marsac, E.C. & Shoshani, J. 2000. African elephant population estimates and distribution: 1995/1999 update. *Elephant* 2(4): 11.

Meng, J., Shoshani, J. & Ketten, D. 1997. Evolutionary evidence for infrasonic sound and hearing in proboscideans. *Journal of Vertebrate Paleontology,* 17: 64A.

Osborn, H.F. 1936. *Proboscidea: a monograph on the discovery, evolution, migration and extinction of the mastodonts and elephants of the world. Vol. I: Moeritherioidea, Deinotherioidea, Mastodontoidea.* New York: The American Museum Press.

Osborn, H.F. 1942. *Proboscidea: a monograph of the discovery, evolution, migration and extinction of the mastodonts and elephants* *of the world. Vol. II: Stegodontoidea, Elephantoidea.* New York: The American Museum Press.

Sanders, W.J. & Miller, E.R. In press. A new proboscidean fauna from the early Miocene site of Wadi Moghara, Egypt. *Journal of Vertebrate Paleontology*.

Shoshani, S.L. (compiler). 2000. Captive elephant population of North America: 1988-1999, and notes on other captive elephants elsewhere in the world. *Elephant* 2(4): 63-71.

Shoshani, J. (consultant ed.). 2000. *Elephants: majestic creatures of the wild* (Revised edition). New York: Checkmark Books.

Shoshani, J. & Eisenberg, J.F. 1982. *Elephas maximus*. *Mammalian Species*, 182: 1-8.

Shoshani, J., Golenberg, E.M. & Yang, H. 1998. Elephantidae phylogeny: morphological versus molecular results. *Acta Theriologica* 5: 89-122. [Erratum: on page 99, subfamily Elephantinae should include *Primelephas* as shown in Table 1, page 93].

Shoshani, J. Goren- Inbar N. & Rabinovitch, R. 2001 A Stylohyoideum of *Palaeoloxdon antiquus* from Gesher Benot Ya'aqov, Israel: morphology and functional inferences. *This volume*.

Shoshani, J. & Marchant, G.H. 2001 The hyoid apparatus: a little known complex of bones and its 'contribution' to proboscidean evolution. *This volume*.

Shoshani, J. & Tassy, P. (eds). 1996. *The Proboscidea: evolution and palaeoecology of elephants and their relatives*. Oxford: Oxford University Press.

Sukumar, R. & Santiapillai, C. 2000. Asian elephant population estimates and distribution: 1999 update. *Elephant* 2(4): 12.

Tassy, P. 1985. *La place des mastodontes miocènes de l'ancien monde dans la phylogénie des Proboscidea (Mammalia): hypothèses et conjectures*. Thèse de Doctorat en Sciences Naturelles, Université Pierre et Marie Curie, Paris. Unpublished.

The timing of early Elephantinae differentiation: the palaeontological record, with a short comment on molecular data

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SUMMARY: The differentiation of the extant genera *Elephas* and *Loxodonta* among the Elephantinae (including the extinct genera *Primelephas* and *Mammuthus*) occurred during the late Miocene. Earliest known *Loxodonta* is found in Baringo (Kenya) and Nkondo-Kaiso (Uganda) between 7.3-5.4 Ma. Earliest known *Elephas* is found at Lothagam (Kenya), circa 6-7 Ma. This paleontological record is in accordance with molecular data: mitochondrial DNA provide support for the estimation of an original split for (*Mammuthus, Loxodonta*) and (*Elephas*) dated between 5,6-7,0 Ma.

The clade Elephantidae Gray 1821 include four extinct genera, *Stegotetrabelodon, Stegodibelodon*, *Primelephas*, and *Mammuthus*, and the two extant genera *Elephas* and *Loxodonta*, the last four genera form the Elephantinae. Several discoveries during the last twenty years in Africa and Arabian Peninsula document aspects of the pattern of differentiation of Elephantinae, that is, the origin of modern genera, and alter previous schemes (the terms "origin" and "differentiation" are used in the hennigian sense, i.e. : the date of origin of a group is that of its sister-group, the date of differentation of a group is that of its first intragroup dichotomy).

The earliest members of the genera *Loxodonta* and *Elephas* are known in the late Miocene and, consequently are contemporaneous of their once supposed "ancestral" taxa, *Stegotetrabelodon* and *Primelephas*. This chronology alters the old picture of a late Miocene origin of Elephantinae followed by their early Pliocene differentiation, according to schemes inherited from Maglio's work in the 1970's.

Earliest loxodonts are isolated molars labelled "*Loxodonta sp.* "Lukeino stage" " by Tassy (1995). This taxon is found in the late Miocene Formations of Lukeino, Baringo Basin (Kenya) and Nkondo, Nkondo-Kaiso area (Uganda), that is, between 7.3 - 5.4 Ma (Lukeino). Known molars (M2, M3, m3) display loxodont derived features typical loxodont wear facets, loops in contact in the middle of the transverse valleys, whatever the stage of wear, narrower lateral margins of enamel loops) allied to primitive features (low laminar frequency, thick enamel) unknown in Pliocene loxodont species, *L. adaurora* and *L. exoptata*.

Earliest member of *Elephas* is *Elephas* sp. nov. from the upper member of the Nawata Formation, Lothagam area (Kenya) (Tassy in press). Upper Nawata is dated 6.7-5.2 Ma (Leakey *et al.* 1996; McDougall & Feibel, 1999). This new species is based on a juvenile mandible with rt.and lt. dp4 and m1, and a portion of lt.m1or2. The oldest known specimen of the early Pliocene species *Elephas ekorensis*, from the Kubi Algi Fm, Turkana (Kenya) are not older than 4.55 Ma (Maglio 1973). Compared to *Elephas ekorensis*, *Elephas* sp. nov. has a more primitive m1 (less plates, posterior plates with four main cusps only, lower laminar frequency, thicker enamel, lower crown, height index low).

Earliest members of the genus *Mammuthus* lineage are not known in the late Miocene. The controversial species *Mammuthus subplanifrons* from the early Pliocene of Southern Africa and East Africa is still the oldest known so far. In any of the two competing hypotheses (a *Mammuthus-Elephas* clade or a *Mammuthus-Loxodonta* clade), phylogeny and known stratigraphical record imply a ghost lineage for *Mammuthus* of circa 2 million years.

Although the palaeontological material is scarce, these discoveries show that earliest modern elephant lineages are contemporaneous with more primitive late Miocene species, that is, *Primelephas gomphotheroides* from East-Africa (Kalb & Mebrate 1993; Kalb *et al.* 1996; Maglio 1973; Maglio & Ricca 1977; Sanders 1997; Tassy 1986, 1994, in press) and *Stegotetrabelodon syrticus* and *S. orbus* from Northern Africa, Abu Dhabi and East-Africa (Kalb & Mebrate 1993; Kalb *et al.* 1996; Maglio 1973, Maglio & Ricca 1977; Petrocchi 1954; Sanders 1997; Tassy 1986, 1994, 1999, in press). These latter taxa may be better treated as “living fossils” than as “ancestors”.

Molecular data also contribute to tilt back dates of differentiation of recent Elephantinae: *Elephas maximus*, *Loxodonta africana* and *Mammuthus primigenius*. Recent studies on mitochondrial DNA provide support for the estimation of an original split for (*Mammuthus*, *Loxodonta*) and (*Elephas*) dated between 5.6-7.0 (Debruyne, in prep.) The differentiation between *Mammuthus* and *Loxodonta* is thought to have taken place before 4.6 Ma, although reliable fossils of the *Mammuthus* lineage are still lacking in the late Miocene. The separation between extant African elephants (bush and forest forms) can be dated 3.5-5.4 Ma. Thus these two lineages look highly differentiated on molecular data although it might be the result of dramatic demographical variations.

These estimations were performed using a separation date between Proboscidea and Sirenia fixed at 60.0 Ma. Only unbiased and weakly saturated markers (12S rDNA, transversions of the cytochrome b) were examined.

In conclusion, it is very likely that elephantine differentiation already occurred seven million years ago.

REFERENCES

Kalb, J.E. & Mebrate, A. 1993. Fossil Elephantoids from the hominid-bearing Awash Group, Middle Awash Valley, Afar Depression, Ethiopia. *Trans. Ameri. Phil. Soc.* 83: xiv + 1-114. Philadelphia.

Kalb, J.E., Froehlich, D.J. & Bell, G.L. 1996. Phylogeny of African and Eurasian Elephantidae of the late Neogene. In J. Shoshani & P. Tassy (eds.), *The Proboscidea: evolution and palaeoecology of elephants and their relatives*: 101-116. Oxford: Oxford University Press.

Leakey, M.G., Feibel, C.S., Bernor, R. ., Harris, J.M., Cerling, T.E., Stewart, K.M., Storrs, G.W., Walker, A., Werdelin, L. & Winkler, A.J. 1996. Lothagam: a record of faunal change in the late Miocene of East Africa. *J. Vert. Pal.* 16: 556-570.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Amer. Phil. Soc. Philadelphia* 63: 1-149.

Maglio, V.J. & Ricca, A.B. 1977. Dental and skeletal morphology of the earliest elephants. *Verhandel. Kon. Ned. Akad. v. Wet.* 29: 1-51.

McDougall, I. & Feibel, C.S. 1999. Numerical age control for the Miocene-Pliocene succession at Lothagam, a hominoid-bearing sequence in the northern Kenya Rift. *J. Geol. Soc.* 156: 731–745.

Petrocchi, C. 1954. I proboscidati di Sahabi. *Rendi. dell'Acad. Naz. dei XL* 4 (1953-1954): 1-66.

Sanders, W.J. 1997. Fossil Proboscidea from the Wembere-Manonga Formation, Manonga Valley, Tanzania. In T. Harrison (ed.), N*eogene Paleontology of the Manonga Valley, Tanzania* Volume 14 of Topics in Geobiology: 266-310. New York: Plenum Press.

Tassy, P. 1986. *Nouveaux Elephantoidea (Mammalia) dans le Miocène du Kenya.*

Paris: Cahiers de Paléontologie (Trav. Paléont. Est-Afr.), Editions du CNRS.

Tassy, P., 1995. Les proboscidiens (Mammalia) fossiles du Rift Occidental, Ouganda. In B. Senut & M. Pickford (eds.), *Geology and Palaeobiology of the Albertine Rift Valley Uganda-Zaire, Vol. 2: Paléobiologie/ Palaeobiology*: 215-255. Orléans: Centre International pour la Formation et les Echanges Géologiques, Publ. Occas. 29 (1994).

Tassy, P. 1999. Miocene elephantids (Mammalia) from the Emirate of Abu Dhabi, United Arab Emirates: palaeobiogeographic implications. In P. J. Whybrow & A. Hill (eds.), *Fossil Vertebrates of Arabia*: 209-233. New Haven: Yale University Press.

Tassy, P. In press. Elephantoidea from Lothagam. In M. G. Leakey & J. M. Harris (eds.) *Lothagam: the dawn of humanity in eastern Africa*. New York: Columbia University Press.

A statistical appraisal of molecular and morphological evidence for mammoth-elephant relationships

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SUMMARY: We present a DNA sequence analysis of the relationship between *Mammuthus, Loxodonta* and *Elephas*, and apply statistical techniques to compare the support for different trees. A *Loxodonta-Mammuthus* clade has the strongest support, but *Elephas-Mammuthus* cannot be ruled out. In morphological characters, several features which have been cited in support of an *Elephas-Mammuthus* relationship are convergent or primitive. The relationship among these three genera is still unresolved.

1. INTRODUCTION

Dental and skeletal morphology have been taken to indicate that *Elephas* and *Mammuthus* are more closely related than either is to *Loxodonta* (Kalb & Froehlich 1995; Shoshani *et al.* 1998). DNA sequence data have produced conflicting results: H.Yang et al. (1996) and Ozawa *et al.* (1997) suggest an *Elephas-Mammuthus* relationship, while Hagelberg *et al.* (1994), Noro *et al*. (1998) and Barriel *et al.* (1999) favoured a *Loxodonta-Mammuthus* clade.

2. MOLECULAR STUDY

DNA was obtained from bone of five *M. primigenius* individuals from Siberian permafrost localities, and blood of 14 *E. maximus* and eight *L. africana*. DNA extraction from *M. primigenius* bone was as described in Hagelberg & Clegg (1991). Further preparation and sequencing was carried out as described in Thomas *et al.* (1997, 1998). A 567 base pair (bp) fragment of the cytochrome *b* gene was amplified from extracted DNA.

Comparison of the 27 sequences revealed ten haplotypes: four *Mammuthus,* three Loxodonta and three Elephas. We first conducted phylogenetic analysis using dugong as the outgroup. Twelve equally parsimonious trees were found (each requiring 163 steps); all had the same basic topology (Fig.1). The bootstrap score of 84% (1000 replicates) suggests that *Loxodonta* and *Mammuthus* are sister taxa. However, the

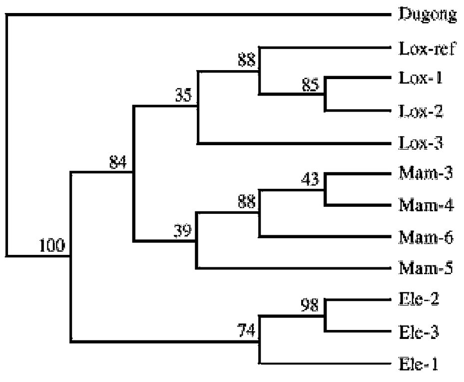

Fig.1 - Bootstrap consensus parsimony tree of elephantid cytochrome *b* sequences. The number at each node represents the percentage with which that group of sequences occurred in the 1000 bootstrap replicates.

Lox = *Loxodonta africana,*
Mam = *Mammuthus primigenius,*
Ele = *Elephas maximus.*

percentages on the nodes delineating each of these two species are low (35 and 39%, respectively).

Maximum-likelihood analysis gave a tree topology identical to one of the most parsimonious trees, and differing from the consensus parsimony tree only in the placement of one mammoth (Thomas *et al.* 2000). By using a Sirenia-Proboscidea split of 65 Ma for calibration, the divergence of the *Elephas* branch was estimated at 14.8 Ma ago, the *Mammuthus-Loxodonta* node at ca. 9.4 Ma ago. In contrast, fossil evidence places the origin of the Elephantidae at ca. 9 Ma ago, the earliest *Loxodonta* at ca. 5.5-6.0 Ma, *Mammuthus* tentatively at 4.0-4.5 Ma, and *Elephas* some 4.0-4.5 Ma (Kalb & Mebrate 1993; Kalb *et al.* 1996; Tassy 1986, 1995).

A possible reason for differences between fossil and molecular dates is lineage sorting, in other words that mtDNA coalescence for the Family Elephantidae, reflected in the cytochrome *b* tree, pre-dates the taxonomic origin of the family. We have shown, using plausible assumptions about divergence dates and population sizes, that there is a significant possibility the gene tree is not congruent with the species tree (Thomas *et al.* 2000). For future work, the use of many independent loci should overcome this problem. Another possible explanation for the high age estimates could be a faster rate of mtDNA evolution in Proboscidea than in Sirenia. To test this, a likelihood ratio test (Felsenstein 1995) compared the tree obtained under the assumption of a molecular clock with an unrooted version of the same tree. The small p-value ($0,05<p<0.1$) suggests rate variation among the elephantid lineages, so the DNA-estimated divergence dates must be treated with caution.

Because of the ancient divergence of elephants and dugong, and dissimilarity in their mtDNA transition-transversion ratios, dugong appears problematic as an outgroup. As an alternative way of locating the root of the tree, maximum-likelihood analysis was performed on the ingroup species only, with and without the assumption of a molecular clock and using two substitution models in the PAML package (Yang Z. 1997). The same tree was obtained under all conditions, and a likelihood ratio test showed no significant difference between the clock and the no-clock models. Thus, within the Elephantidae, the molecular clock assumption holds. The root can therefore be located without an outgroup, and indicates an overall (Ele (Lox, Mam)) topology. Two methods were then used to assess the support for this topology. Using bootstrap proportions (Felsenstein 1995), a monophyletic Lox-Mam clade was supported in 67% of replicates, whereas a monophyletic Ele-Mam clade was supported in 29%. Using the Bayesian method of Yang Z. & Rannala (1997), the posterior probability score for the Lox-Mam clade was only 0.43. Moreover, the second and third best trees, with posterior probabilities of 0.28 and 0.20, respectively, grouped *Mammuthus* and *Elephas*.

To assess claims of resolution of elephantid phylogeny using American mastodon cytochrome b sequences (Yang H. *et al.* 1996), we constructed parsimony (with 1000 bootstrap resamplings) and maximum-likelihood trees using Yang H. *et al.*'s mastodon sequence instead of dugong as the outgroup, and combined all the sequences in our previous analysis, plus the *Mammuthus* and elephant sequences of Yang H. *et al.* (1996) and the *Mammuthus* and *Elephas* sequences of Ozawa *et al.* (1997). Bootstrap support for most ingroup branches was poor. Despite a number of tree topologies with different methods, one consistent feature was that the *Mammuthus* sequences of Yang H. *et al.* (1996) always formed a clade with *Elephas*, whereas the *Mammuthus* sequences of this study and of Ozawa *et al.* (1997) fell outside the *Elephas* clade (see also Derenko *et al.* 1997, Barriel *et al.* 1999). A monophyletic grouping of all the *M. primigenius* sequences is supported in only 0.018% of replicates. This degree of variation among the sequence data obtained from different M. primigenius samples is unexpected and at present unexplained.

3. MORPHOLOGICAL STUDY

Morphological characters for *Mammuthus*, *Loxodonta* and *Elephas*, previously cited as evidence of their relationships, were examined on skulls of *M. meridionalis* (Early Pleistocene), *M. primigenius* (Late Pleistocene), *L. africana* and *E. maximus*.

Some characters are autapomorphous, e.g.

• the 'globular skull' of *Loxodonta* which appears, from Kalb & Mebrate's (1993) analysis, to be an autapomorphy, *Elephas* and *Mammuthus* merely retaining the primitive, narrow-skulled condition.

Other characters are convergent, e.g.

• the high cranium of late *Elephas* and *Mammuthus*, since early skulls of each are lower (Maglio 1973; Boeuf 1983; Lister 1996); see figure 2. Correlation with this cranial expansion may account for several other characters that have been described as synapomorphies of *Elephas & Mammuthus*:

• large dorsal parietal bulges (Tassy & Shoshani 1988; Shoshani *et al.* 1998);

• recessed occipital condyles (Kalb & Froehlich 1995; Kalb *et al.* 1996), due to overlapping by the posterior cranium (Fig. 2);

• concave fronto-parietal region (Kalb & Froehlich 1995; Kalb *et al.* 1996; Shoshani *et al.* 1998), a feature which has been linked (Tassy & Shoshani 1988; Tassy 1996) to the large dorsal parietal bulges.

• numerous enamel lamellae in the molars of late representatives of *Elephas* and *Mammuthus*, mentioned as a synapomorphy by various authors (e.g. Tassy & Shoshani 1988). The earliest representatives of these genera have no more lamellae than the earliest *Loxodonta* (Maglio 1973; Fig. 2).

Three published characters may be phylogenetically informative:

• gracile stylohyoid bone (Tassy & Shoshani 1988; Tassy 1996; Shoshani *et al.* 1998), linking *Elephas & Mammuthus.*

• prominent, close maxillary ridges (interalveolar cristae) (Tassy & Shoshani 1988; Tassy 1996; Shoshani *et al.* 1998). Our observations confirm this character as valid in the terminal species *M. primigenius* and *E. maximus*; and illustrations in Boeuf (1983) indicate that it occurs in the more primitive *M. meridionalis* too, linking *Elephas* and *Mammuthus*.

• flared premaxillary bones (Kalb & Froehlich 1995), apparently linking *Loxodonta* and *Mammuthus*. This character appears in the earliest *Mammuthus*, but in later *Mammuthus* the premaxillaries are subparallel and not at all flared (Lister 1996), apparently convergent to *Elephas*. Conversely in some later *Elephas* (e.g. *E. antiquus*) they are very strongly flared

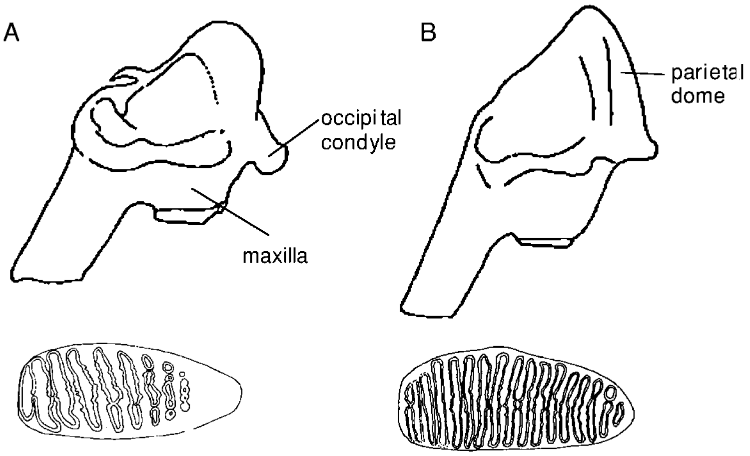

Fig.2 - Skulls and molars of (A) *Mammuthus meridionalis*, (B) *M. primigenius*, showing derived features of expanded parietal domes, less prominent occipital condyles, deep maxilla (and hypsodont molars) and high lamellar frequency, all appear to be convergent to *Elephas maximus*. After Lister (1996).

(Maglio 1973; Osborn 1942), apparently convergent to *Loxodonta*. This illustrates the importance of scoring early representatives of each genus.

4. DISCUSSION

Elephantid phylogeny presents a classic three-taxon phylogenetic problem. The fossil data give a framework of 0-5 Ma for the interval between the first and second nodes within the phylogeny. At the lower limit, the nodes may be so close together that their resolution with either molecular or morphological data is difficult. At the upper limit, with the nodes up to 5 Ma apart, sufficient change should have accumulated to allow their resolution. It is hoped that further molecular and morphological work will resolve this question.

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6. REFERENCES

Barriel, V., Thuet, E. & Tassy, P. 1999. Molecular phylogeny of Elephantidae. Extreme divergence of the extant forest African elephant. *C. R. Acad. Sci. Paris* 322: 447-454.

Boeuf, O. 1983. Le site villafranchien de Chilhac (Haute-Loire), France. Etude paléontologique et biochronologique. Thèse d'Etat, Universite de Paris VII, France.

Derenko, M., Malyarchuk, B. & Shields, G.F. 1997. Mitochondrial cytochrome b sequence from a 33,000-year-old woolly mammoth (*Mammuthus primigenius*). *Ancient Biomolecules* 1: 149-153.

Felsenstein, J. 1995. PHYLIP (Phylogeny Inference Package), v. 3.57c. University of Washington.

Hagelberg, E. & Clegg, J.B. 1991. Isolation and characterization of DNA from archaeological bone. *Proc. R. Soc. Lond. B* 244: 45-50.

Hagelberg, E., Thomas, M.G., Cook Jr, C.E., Sher, A.V., Baryshnikov, G.F. & Lister, A.M. 1994. DNA from ancient mammoth bones. *Nature* 370: 333-334.

Kalb, J.E. & Froelich, D.J. 1995. Interrelationships of late Neogene elephantoids: new evidence from the Middle Awash Valley, Afar, Ethiopia. *Geobios* 28: 727-736.

Kalb, J.E. & Mebrate, A. 1993. Fossil elephantoids from the hominid-bearing Awash Group, Middle Awash Valley, Afar Depression, Ethiopia. *Trans. Am. Phil. Soc.* 83: 1-114.

Kalb, J. E., Froehlich, D.J. & Bell, G.L. 1996. Phylogeny of African and Eurasian Elephantoidea of the late Neogene. In Shoshani & Tassy: 101-116.

Lister, A.M. 1996. Evolution and taxonomy of Eurasian mammoths. In Shoshani, J. & Tassy, P.: The Proboscidea 203-213. Oxford: Oxford Univesity Press.

Maglio, V.J. 1973. Origin and evolution of the Elephantidae. *Trans. Am. Phil. Soc.* 62: 1-149.

Noro, M., Masuda, R., Dubrovo, I.A., Yoshida, M.C. & Kato, M. 1998. Molecular phylogenetic inference of the woolly mammoth Mammuthus primigenius, based on complete sequences of mitochondrial cytochrome b and 12S ribosomal RNA genes. *J. Mol. Evol.* 46: 314-326.

Osborn, H.F. 1942. *Proboscidea, vol. 2*. New York: American Museum of Natural History.

Ozawa, T., Hayashi, S. & Mikhelson, V.M. 1997. Phylogenetic position of mammoth and Steller's sea cow within Tethytheria demonstrated by mitochondrial DNA sequences. *J. Mol. Evol.* 44: 406-413.

Shoshani, J., Golenberg, E.M. & Yang, H. 1998. Elephantidae phylogeny: morphological versus molecular results. *Acta Theriologica* (Suppl. 5): 89-122.

Shoshani, J. & Tassy, P. (eds) 1996. *The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives*. Oxford: OUP.

Tassy, P. 1986. Nouveaux Elephantoidea (Mammalia) dans le Miocène du Kenya. *Cahiers de Paléontologie Est-Africaine*. Paris: CNRS.

Tassy, P. 1995. Les proboscidiens (Mammalia) fossiles du Rift occidental, Ouganda. In *Ge-*

ology and Palaeobiology of the Albertine Rift Valley, Uganda-Zaire. II. Palaeobiology: 217-257. CIFEG Occasional Publications 1994/29. Orleans.

Tassy, P. 1996. Who is who among the Proboscidea? In Shoshani & Tassy: 39-48.

Tassy, P. & Shoshani, J. 1988. The Tethytheria: elephants and their relatives. In M.J. Benton (ed.), *The phylogeny and classification of tetrapods. II. Mammals*: 283-315. Oxford, UK: Clarendon.

Thomas, M.G., Hagelberg, E., Jones, H.B., Yang, Z. & Lister, A.M. 2000. Molecular and morphological evidence on the phylogeny of the Elephantidae. *Proc. R. Soc. Lond B.* 267: 2493-2500.

Thomas, M.G., Hesse, S.A., Foss, Y.J. & Farzaneh, F. 1997. The use of PCR for differential screening of cDNA libraries. In White, B. A. (ed.), *PCR cloning protocols*: 405-418. Totowa: Humana.

Thomas, M. G., Cook Jr, C. E., Miller, K. W. P., Waring, M.J. & Hagelberg, E. 1998. Molecular instability in the COII/ tRNALys intergenic region of the human mitochondrial genome: multiple origins of the 9-bp deletion and heteroplasmy for expanded repeats. *Phil. Trans. R. Soc. Lond. B* 353: 955-965.

Yang, H., Golenberg, E.M. & Shoshani, J. 1996. Phylogenetic resolution within the Elephantidae using fossil DNA sequence from the American mastodon (*Mammut americanum*) as an outgroup. *Proc. Natl Acad. Sci. USA* 93: 1190-1194.

Yang, Z. 1997. PAML: a program for package for phylogenetic analysis by maximum likelihood. *CABIOS* 13: 555-556.

Yang, Z. & Rannala, B. 1997. Bayesian phylogenetic inference using DNA sequences: a Markov chain Monte Carlo method. *Mol. Biol. Evol.* 14: 717-724.

African *Elephas recki*: time, space and taxonomy

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SUMMARY: The African *Elephas* lineage has traditionally been very important for faunal correlation of African paleontology localities, due to the division of the intermediate member, *Elephas recki*, into five time-successive subspecies. This lineage has been proposed as an example of anagenetic change, with each species and/or subspecies evolving directly into the next with no overlap in time. Results from comparison of dental variability in *Elephas recki* to both extant elephant species as well as other African and Eurasian fossil elephants indicate that the variation in the sample of specimens currently attributed to *Elephas recki* exceeds that of many other species, with great variation at the subspecies level as well. Consolidation of the published records of *Elephas recki* subspecies indicate that the ranges for all five subspecies overlap, and are not separated in time as previously proposed. The significant degree of temporal overlap, combined with the wide range in morphological variation suggests that this is not a single species, and a preliminary proposal for taxonomic revision is discussed.

1. INTRODUCTION

The African *Elephas* lineage, consisting of *Elephas ekorensis*, *Elephas recki*, and *Elephas iolensis*, has been very important for faunal correlation in East Africa, and to some extent in South Africa (Beden 1983, 1987; Bromage *et al.* 1995; Cooke & Coryndon 1970; Cooke 1993; Brooks *et al.* 1995; Brunet *et al.* 1995; Coryndon 1972; Harris *et al.* 1988; Harrison & Baker 1997; Hill *et al.* 1992; Kalb & Mebrate 1993; Maglio 1970, 1973; Sanders 1990; White & Suwa 1984). This is due largely to the division of the intermediate member, *Elephas recki*, into five time-successive subspecies, *Elephas recki brumpti*, *Elephas recki shungurensis*, *Elephas recki atavus*, *Elephas recki ileretensis*, and *Elephas recki recki* (Beden 1979). This lineage has been proposed as an example of anagenetic change, with each species and/or subspecies directly evolving into the next with no overlap in time. In addition, the first and terminal species in the lineage, *Elephas ekorensis* and *Elephas iolensis* respectively, have been proposed as extensions of *Elephas recki*, and all three of these species representing successive stages in one lineage (Cooke & Maglio 1972).

There has been very little quantitative analysis of the variation within *Elephas* species and subspecies, with most researchers relying heavily on descriptions of species and subspecies from previous studies (Maglio 1973; Beden 1979, 1983, 1987a, b). As a result, specimens of *Elephas* are often identified based on the inferred age of the locality, and then used as evidence to support an estimated age. Identification of specimens using this circular reasoning has only confounded the definition and description of each species and subspecies, and increased the heterogenous nature of the specimens assigned to each.

There are two problems with the current accepted anagenetic scheme for the African *Elephas* lineage. First, the variability in each sample of specimens attributed to species and subspecies needs to be reexamined. Second, more crucial to the utility of the members of this lineage as biochronological markers for African localities, a comprehensive survey of faunal assemblages including *Elephas* needs to be done in order to redefine the time ranges for the species and subspecies within the lineage. If the species and subspecies overlap in time and the variation within each taxonomic unit is high, then the evolution of the lineage can no longer be considered as anagenesis, and the usefulness of the African *Elephas* lineage as a biostratigraphic marker will be in question.

2. METHODS

Crania, mandibles and dentition for 25 fossil species and 2 extant elephants have been examined by the author, and this dataset includes 1050 molars (572 fossil molars, 478 extant molars), 142 crania (16 fossil, 126 extant), and 109 mandibles (26 fossil, 83 extant). Species included in this analysis: *Loxodonta africana*, *Elephas maximus* (extant elephants), and *Elephas recki*, *Elephas antiquus*, *Loxodonta adaurora*, and *Mammuthus colombi* (fossil elephants). The extant elephants were used as a model for studying variability in fossil taxa because there are abundant specimens of all age groups, and also because the two living species have been divided into subspecies, providing a comparison for the subspecies in the African *Elephas* lineage. A fossil species from each genus was also included for comparison.

The set of dental measurements used in this study follow the methodology outlined in Todd (1997) after Maglio (1973), Beden (1979), Roth and Shoshani (1988) and Roth (1992). These measurements include those made on overall tooth dimensions, as well as those made on each individual tooth plate (Todd, 1997). The degree of morphological variation in *Elephas recki* was compared to the extant species and other fossil elephants in comparison of coefficient of variation and analysis of variance with Tukey-Kramer pairwise mean comparisons. All six molars were examined. Although crania and mandibles are included in the general dataset, sample sizes for the fossil species are too currently too small for reliable statistical testing, and the main focus thus far has been on dentition.

A comprehensive survey of the literature as well as provenience of the specimens included in this study was completed to establish first and last appearances of species and subspecies throughout Africa. This list relies heavily on published accounts of accurately dated fossil localities, but is the most current for the African Elephantidae. As this is a test of the currently accepted fossil taxa, the original taxonomic identification of specimens (as previously published) was retained unless there was an obvious error (such as a tooth identified as Elephas, which should be allocated to Loxodonta).

3. RESULTS

The first and last appearances of each *Elephas recki* subspecies have been greatly expanded from previous papers. When time ranges are consolidated, it is apparent that all ranges for *Elephas recki* subspecies overlap, and are not separated in time as previously proposed (Fig. 1). In many cases, different subspecies have been identified from the same stratigraphic members at certain localities.

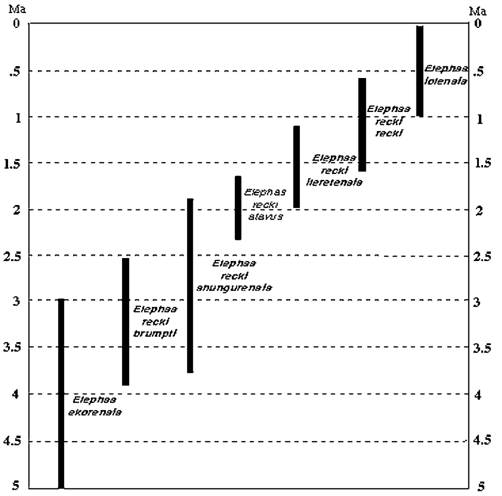

Fig.1 - Revised biochronology of the African *Elephas* lineage. The maximum age for each first appearance is the maximum age estimate for the locality that marks the first appearance of each taxon. The minimum age for each last appearance is the minimum age estimate for the locality that marks the last appearance of each taxon.

Results from comparison of cranial and dental variability in *Elephas recki* to both extant elephant species as well as many other African and European fossil elephants (Todd, 1997), indicate that the overall variation in the sample of specimens currently attributed to *Elephas recki* is consistently high for all measurements on all six molars.

At the subspecies level, the variance in *Elephas recki* exceeds the variance in the extant Asian elephant as well as the African elephant and *Loxodonta adaurora*. This high degree of variation cannot be attributed to geographic differences, as much of the variability occurs in samples of specimens collected from the same sites. *Elephas recki* consistently had higher coefficients of variation and higher variance than the other species in the sample. This high degree of variability was present in all six teeth (dp2, dp3, dp4, M1, M2, M3).

Although the variance is high in individual subspecies of *Elephas recki*, there is considerable morphological overlap in lamellar frequency, enamel thickness, enamel folding and amplitude of folding, height, length and width, all measurements which have been established as reliable for species identification purposes. As a result, it is difficult to separate some of the subspecies on metric data alone. *Elephas recki shungurensis*, *Elephas recki atavus* and often *Elephas recki ileretensis* are indistinguishable from each other in many instances. *Elephas recki brumpti* groups by itself and *Elephas recki recki* usually groups alone, although sometimes it overlaps with *Elephas recki ileretensis*. An example of this overlap is included in figure 2.

4. CONCLUSIONS

The time ranges for recorded occurrences of each subspecies of *Elephas recki* are not consecutive, but overlap significantly (Fig. 1). This overlap cannot support an anagenetic mode of evolution as previously proposed, and cladogenesis must be inferred (MacFadden 1992). Whether the African *Elephas* lineage represents a branching tree with multiple species (as suggested by the "true" definition of cladogenesis), remains to be determined. The results of this analysis indicate that the traditional view of an anagenetic model cannot be supported.

Based on the morphometric analysis, there are several conclusions that can be made about the African *Elephas* lineage. First, when compared with the extant elephants, the variation present in *Elephas recki* dentition exceeds what is expected for a single species. This variation suggests different taxonomic scenarios: 1) *Elephas recki* is not a single species, 2) the sample of specimens currently attributed to *Elephas recki* includes specimens which may belong in other taxa. Both of these are currently under review by the author and will be presented in the future.

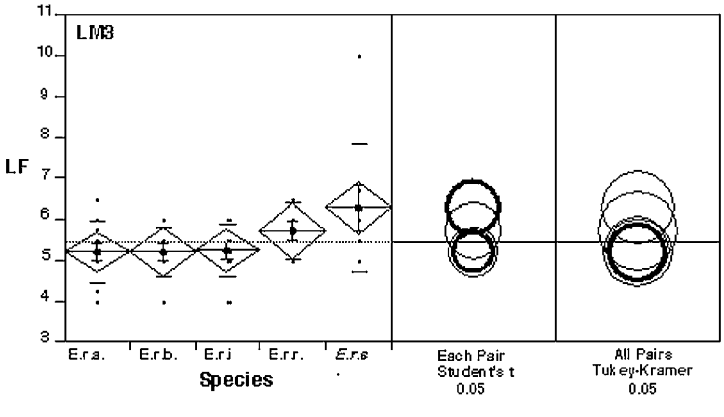

Fig.2 - Range of variation and overlap of means for subspecies of *Elephas recki* lower third molars indicate no significant difference between *Elephas recki atavus*, *Elephas recki brumpti*, and *Elephas recki ileretensis* for lamellar frequency (*Elephas recki atavus* is in bold text).

The second conclusion is that the subspecies of *Elephas recki* are not distinct from each other in morphology or time range. *Elephas recki brumpti* and *Elephas recki recki* group separately from the rest of the subspecies, while *Elephas recki shungurensis*, *Elephas recki atavus* and part of *Elephas recki ileretensis* group together. Part of *Elephas recki ileretensis* groups with *Elephas recki recki* in some measurements. The implications of this second conclusion are significant in that it is no longer possible to identify discreet characteristics on individual specimens for species and subspecies identification. As this is not in discordance with the chronological revision, tentative identifications based on relative time period are also problematic.

Any revision of the African *Elephas* lineage will have consequences for biostratigraphic correlation. If *Elephas recki* is a single species with a long time range but few if any subdivisions (subspecies), then its use as a faunal biochron will be limited. Conversely, if there is more than one species in the *Elephas recki* sample, then elephantid diversity during the Plio-Pleistocene of Africa is much greater than previously thought.

Careful analysis of the current state of the African *Elephas* lineage has broad implications for evolutionary scenarios and identification of Plio-Pleistocene elephantids. This is not limited to *Elephas*, as work in progress on *Loxodonta* and *Mammuthus* also indicates wide ranges of variation in measurements and non-metric characters. There are general morphological similarities between subsets of African *Elephas* specimens and Eurasian species, leading to further questions concerning radiations out of Africa, overall elephantid diversity and evolutionary change in the Plio-Pleistocene. There are also temporal and geographical discrepancies which need to be examined in greater detail. Even though adequate numbers of measurements on cranial, mandibular and post-cranial specimens are difficult to obtain because of small samples, non-metric characters will definitely supplement the dental data and need to be included for taxonomic revision.

Is *Elephas recki* a chronospecies or paleospecies? Comparisons with other paleo- and living taxa suggest that current assumptions about *Elephas recki* subspecies as morphologically and temporally discreet units are no longer valid. Revision and reorganization of samples currently attributed to each taxon is currently in progress by the author. *Elephas recki* may still be a valid species, but may be part of a more diverse lineage of African *Elephas* than previously proposed. This revision must encompass analysis of the other African lineages, *Loxodonta* and *Mammuthus*, and a comparative, holistic approach to a revision of the African Elephantidae is necessary.

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6. REFERENCES

Beden, M. 1979. Les éléphants (*Elephas* et *Loxodonta*) d'Afrique orientale: systématique, phylogénie, intéret biochronologique. Thèse de Doctorat d'Etat. Poitiers.

Beden, M. 1983. Elephantidae. In Harris, J.M. (ed.), *Koobi Fora Research Project Vol. II, The Fossil Ungulates: Proboscidea, Perissodactyla, and Suidae*: 40-129. Oxford: Clarendon Press.

Beden, M. 1987a. Fossil Elephantidae from Laetoli. In Leakey, M. D. & J. Harris (eds), *Laetoli: A Pliocene Site in northern Tanzania*: 259-297. New York: Oxford University Press.

Beden, M. 1987b. *Les Faunes Plio-Pléistocènes de la Vallée de l'Omo (Éthiopie), Tome 2: Les Eléphantidés*. Cahiers de Paléontologie. Paris.

Bromage, T.G., Schrenk, F. & Juwayeyi, Y.M. 1995. Paleobiogeography of the Malawi Rift: age and vertebrate paleontology of the

Chiwondo Beds, northern Malawi. *Journal of Human Evolution* 28: 37-57.

Brooks, A.S., Helgren, D.M., Cramer, J.S., Franklin, A., Hornyak, W., Keating, J.M., Klein, R.G., Rink, W.J., Schwarcz, H., Leith-Smith, J.N., Steward, K., Todd, N.E., Verniers, J. & Yellen, J.E. 1995. Dating and context of three Middle Stone Age sites with bone points in the Upper Semliki Valley, Zaire. *Science* 268: 548-553.

Brunet, M., Beauvilain, A., Coppens, Y., Heintz, E., Moutaye, A.H.E. & Pilbeam, D. 1995. The first australopithecine 2,500 kilometres west of the Rift Valley (Chad). *Nature* 378: 273-274.

Cooke, H.B.S. 1993. Fossil proboscidean remains from Bolt's Farm and other Transvaal cave breccias. *Palaeontologica Africana* 30: 25-34.

Cooke, H.B.S. & Maglio, V.J. 1972. Plio-Pleistocene stratigraphy in East Africa in relation to proboscidean and suid evolution. In Bishop, W. W. & J. A. Miller (eds.), *Calibration of Hominoid Evolution*: 303-329. Edinburgh: Scottish Academic Press.

Cooke, H.B.S. & Coryndon, S.C. 1970. Pleistocene Mammals from the Kaiso Formation and other related deposits in Uganda. In Leakey, L.S.B. & R.J.G. *Savage, Fossil Vertebrates of Africa, 2*. New York: Academic Press.

Coryndon, S.C., Gentry, A.W., Harris, J.M., Hooijer, D.A., Maglio, V.J. & Howell, F.C. 1972. Mammalian remains from the Isimila prehistoric site, Tanzania. *Nature* 237: 292.

Hill, A., Ward, S. & Brown, B. 1992. Anatomy and age of the Lothagam mandible. *Journal of Human Evolution* 22: 439-451.

Kalb, J.E. & Mebrate, A. 1993. Fossil Elephantoids from the Hominid-Bearing Awash Group, Middle Awash Valley, Afar Depression, Ethiopia. *Transactions of the American Philosophical Society.* 83, 1: 1-14.

MacFadden, B.J. 1992. *Fossil Horses: Systematics, Paleobiology, and Evolution of the Family Equidae*. Cambridge: Cambridge University Press.

Maglio, V.J. 1973. Origin and Evolution of the Elephantidae. *Transactions of the American Philosophical Society.* 63, 3: 1-149.

Maglio, V.J. 1970. Early Elephantidae of Africa and a tentative correlation of African Plio-Pleistocene Deposits. *Nature* 225: 328-332.

Roth, V.L. 1992. Quantitative variation in elephant dentitions: implications for the delimitation of fossil species. *Paleobiology*. 18(2): 184-202.

Roth, V.L., & Shoshani, J. 1988. Dental identification and age determination in Elephas maximus. *Journal of Zoology* 214:567-588.

Sanders, W.J. 1990. Fossil proboscidea from the Pliocene Lusso Beds of the Western Rift, Zaire. *Virginia Mus. Nat. Hist. Mem.* 1: 171-187.

Todd, N.E. 1997. *Comparison of Variation in Cranial and Dental Morphology of Elephas recki and the Extant Elephants: Implications for Phylogeny and Macroevolution*. Ph. D. Thesis. George Washington University.

White, T.D., Moore, R.V. & Suwa, G. 1984. Hadar Biostratigraphy and Hominid Evolution. *Journal of Vertebrate Paleontology* 4: 575-581.

Last occurrences of large mammals and birds in the Late Quaternary of the Italian peninsula

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SUMMARY: The late Quaternary vertebrate assemblages of the Italian peninsula are characterized by the progressive extinction of those large mammals which date back to the Middle Pleistocene, and by the expansion of some “cold” taxa-both mammals and birds. The longest-surviving taxa include *Crocuta crocuta, Panthera spelaea, Equus ferus, Equus hydruntinus, Megaloceros giganteus* and *Bison priscus,* while *Hippopotamus, Elephas* and *Stephanorhinus* survived until OIS 5a, 4 and 3 respectively. In the coldest phases *Nyctea scandiaca* and *Pinguinus impennis* among the birds, and the mammals *Mammuthus*, *Coelodonta* and *Gulo*, became widespread in the south-eastern part of the Italian peninsula and subsequently became extinct during the Tardiglacial. In addition, *Alces alces* was present in the northwest of the Italian peninsula during OIS 4 and 2, whereas *Rangifer tarandus* reached the westernmost border of Italy.

1. INTRODUCTION

The peculiar geographical position and morphology of the Italian peninsula, and the presence of natural physical barriers, affected the distributions of vertebrates and local speciations. This enable us to recognize the continental Plio-Pleistocene mammal associations of Italy as Faunal Units (FUs) of regional significance, with differing times of colonisation with respect to the rest of continental Europe, especially during the late Glacial phases. Moreover, in Italy the Mediterranean Sea, which surrounds the greatest part of its territory, seems to have softened the glacial/interglacial climatic extremes, resulting in the existence of refugia for several species (Alberdi *et al.* 1998).

2. DISCUSSION

Due to several factors, it is difficult to determine the chronology of the occurrences and extinctions of Late Quaternary mammals and birds. The Italian peninsula is characterised by several distinct biogeographical areas, related to the presence of different migration paths, linked to sea level-climatic phases and to local climatic and microclimatic factors. Moreover, several faunal assemblages show the coexistence of taxa of different geographical origins and palaeoenvironmental habits. Few sites have a stratigraphical sequence long enough to record the real changes in faunal composition; and selective factors, such as the influence of human populations and the activities of predators, have modified the faunal composition of the assemblages. The absence of stratigraphical data for the old collections and for isolated fossils add to the difficulties of reconstructing the colonisation of the Italian peninsula by mammals.

The available data enable us to point out some considerations.

Among the “pachyderms” of Middle Pleistocene origin *Elephas antiquus* survived until

OIS 4. The occurrence of the elephant in the OIS 3 needs to be confirmed by further better defined discoveries. The presence of *Hippopotamus* is not recorded after the end of OIS 5, while *Stephanorhinus* together with *Dama dama dama* seems not to have survived OIS 3.

Among the large carnivores *Panthera pardus* definitely occurs during OIS 3, while the presence of the lion is testified by fossil bones in the temperate phase before 30 ky, and is represented in palaeolithic art referable to OIS 2. Also the cave lion survives into the early Holocene at Fredian Shelter (Tuscany) (Boschian *et al.* 1995). *Crocuta crocuta* and *Ursus spelaeus* seem to occur until the end of the Epigravettian.

Finally, *Equus hydruntinus* survives until the beginning of the Holocene, while *Equus ferus* has been recorded in the Tardiglacial (OIS 2). Alces alces (Gallini & Sala 2001) and *Rangifer tarandus* are sporadic elements of the mammal faunas of northern Italy. *Alces alces* probably came from the Balkan area and became widespread in the Po plain during OIS 4, surviving throughout OIS 2. Coming from western Europe, *Rangifer tarandus* reached only the coastal region of Alpi Marittime, but did not enter northern Italy. The geographical distribution of these species and their migration pathways are still poorly known, but these cervids did not become widespread in the Italian peninsula, probably because of the Apennine natural barrier. On the other hand, the occurrence of “cold taxa” such as *Mammuthus primigenius, Coelodonta antiquitatis, Gulo gulo* (Sardella 2001) and *Alopex lagopus* in sites on the southern Adriatic coast, characterised by cold but dry climatic conditions, suggest a hpothesis of unfavourable environments for *Alces* diffusion.

Some problems involve the occurrence and/or the survival of other “cold” taxa such as *Mammuthus primigenius* and *Alopex lagopus.* Woolly mammoth certainly occurred in OIS 3, but the persistence of this taxon during the OIS 2 remains to be proved. It is possible that arctic fox, as well as the last jackal-like dog, are present in the latest Glacial fauna of Romanelli cave (Tagliacozzo, pers. comm.), but these data need to be confirmed.

During the Middle Pleistocene the modern species of avifauna seem to be already widespread in the Mediterranean area. In the Late Quaternary birds typical of cold climate condition, such as *Nyctea scandiaca, Pinguinus impennis* and perhaps *Falco rusticolus occurred. Lagopus* and *Pyrrhocorax*, today showing a less extensive geographic distribution range, were very frequent in the Italian peninsula probably until OIS 2 (Pavia 2000).

3. CONCLUSION

The late Quaternary vertebrate assemblages of the Italian peninsula are characterized by differential survival and progressive extinction of the large mammals of Middle Pleistocene tradition. Pachyderms have been most affected by clmatic deterioration. *Hippopotamus* survived only until the end of the OIS 5a, whereas *Elephas antiquus* occurred also during OIS 4 and *Stephanorhinus* was still present during OIS 3. *Crocuta crocuta, Panthera spelaea, Equus ferus, Equus hydruntinus, Megaloceros giganteus* and *Bison priscus* can be considered as long surviving taxa. *Mammuthus, Coelodonta* and *Gulo* were widespread in the south-eastern part of the Italian peninsula during OIS 4; the carnivores become extinct during Tardi-Glacial time, while the definite occurrence of mammoth during OIS 2 needs to be confirmed. In the coldest phases of the Pleniglacial some “cold” taxa, both mammals and birds, have been recorded. *Nyctea scandiaca* and *Pinguinus impennis* were widespread throughout the peninsula, while *Alces alces* occurred in the north-west of the peninsula during OIS 4 and 2. *Rangifer tarandus* reached the westernmost geographical boundary of the Italian coast, whereas *Alopex lagopus* probably occurred in the Adriatic region.

4. REFERENCES

Alberdi, M.T., Caloi, L., Dubrovo, I., Palombo, M.R. & Tsoukala, E. 1998. Large Mammal faunal complexes and palaeoenvironmental changes in the Late Middle and Late Pleistocene: a preliminary comparison between the Eastern Europe and the Mediterranean areas. *Geologija*, 25: 8-19.

Boschian, G. Mallegni, F. & Tozzi, C. 1995. The Epigravettian and Mesolithic site of Fredian Shelter (in Tuscany). *Quaternaria Nova*. 5: 45-80.

Gallini, V. & Sala, B. 2001. Settepolesini di Bondeno (Ferrara – Eastern Po Valley): the first example of mammoth steppe in Italy. *This volume*.

Pavia, M. 2000. *Le avifaune pleistoceniche dell'Italia meridionale.* Doctoral thesis, XIII cycle (1997-2000), Università di Genova, Cagliari and Torino: 1-141. Unpublished.

Sardella, R. 2001. Segnalazione di *Gulo gulo* Linnaeus nel deposito fossilifero del Pleistocene superiore di Ingarano (Foggia, Italia meridionale). *Giornale di Geologia*, 62 (2000): 111-114.

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Mammoths, volcanism and early humans in the basin of Mexico during the Late Pleistocene/Early Holocene

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SUMMARY: The most important Late Pleistocene-Early Holocene fossiliferous localities in the Basin of Mexico are all associated with volcanic and lacustrine sediments. New results from the stratigraphy, tephrachronology and ^{14}C dating from these sites are presented and evaluated. At the Tocuila mammoth site the bones are embedded in lahar derived from a mixture of tephras of different ages which indicates deposition after the Upper Toluca Pumice. ^{14}C dating supports this chronology. The Plinian eruption which produced the Upper Toluca Pumice had a major environmental impact in the Basin and is likely to have killed some megafauna and early humans but also preserved a unique picture of Late Pleistocene life. The association of the Upper Toluca Pumice with two human skulls at Tlapacoya and one at Metro Balderas is proved and hence their chronological status established. In addition one Tlapacoya skull is the first directly dated human in Mexico with an age of 9730 ± 65 years BP.

We present new results from an ongoing research programme looking into the relationships between the palaeoenvironment, megafauna (especially mammoths) and early human presence in the Late Pleistocene deposits around the Basin of Mexico.

This area is rich in Pleistocene sediments associated with a fluctuating lake system. The main localities with mammoth remains have been reported around the shores of the lake, where at least 25 localities with mammoth remains (*Mammuthus columbi*) and other Late Pleistocene Mammals (camel, horse, glyptodon, sabre-toothed cat, bison) have been found. About half of these sites are in association with human presence (obsidian blades, cut marks on bone and Lerma-El Jobo type points), Lorenzo & Mirambell (1986).

The basis of a chronological framework for the Late Pleistocene-Early Holocene of the Basin of Mexico is presented, using stratigraphy, tephrachronology and radiocarbon dating to correlate some of the more important Late Pleistocene fossil localities including Tepexpan, Tocuila, Tequexquinahuac, Tlapacoya and San Vicente Chicoloapan.

Volcanic activity during the Late Pleistocene-Early Holocene has played a very important role in the palaeoenvironment of the Basin of Mexico. Three major volcanic eruptions of Plinian type have been identified producing tephra marker horizons in the area: Great Basaltic-Andesitic Ash (GBA) at ~ 29,000 years BP (Moose 1997), the Pumice with Andesite Tephra (PWA) at ~ 14,450 years BP (Mooser & Gonzalez-Rul 1961; Mooser 1967) and the Upper Toluca Pumice (UTP) at ~ 11,600 years BP (Bloomfield & Valastro, 1974, 1977).

Using the electron microprobe unit at Edinburgh University we were able to analyse tephra shards from several mammoth localities which indicated association with specific volcanic eruptions. The sedimentology indicates that in several sites the mammoth bones are embedded in lahar deposits (volcanic mud flows) which indicate catastrophic flood events in the area with examples from Tocuila, Tequexquinahuac, Tlapacoya and San Vicente Chicoloapan.

The Tocuila site is particularly interesting because the remains of seven mammoths (*Mammuthus columbi*) were found together in an area measuring only 28 m^2 embedded in a layer of reworked volcanic material (lahar). Siebe *et al.* 1999 interpreted the sequence as a lahar derived from the Pumice with Andesite tephra marker (PWA), because chemical analysis of pumice found in the deposit corresponds with the composition of tephra which originated ca. 14,000 years BP from a Plinian eruption of the Popocatepetl Volcano. However radiocarbon dating of the bone layer showed that the lahar deposit was formed no earlier than 10, 650 ± 75 years BP; indicating a large discrepancy in time. One mammoth skull in the bottom of the sequence gave a date of 11,100 ± 80 years BP. Siebe *et al.* 1999 explained the discrepancy of about 3000 years between tephra deposition and the lahar event as due to the lack of water during the Late Pleistocene when permafrost and glacial ice were prevalent.

During the present study we have re-examined the chemical composition of the silty-sandy volcaniclastic sediments in which the mammoths are embedded (Tab. 1) and found that indeed there are andesitic pumices associated with the PWA eruption, with silica values around 61% but that there were present as well tephra shards associated with the Upper Toluca Pumice (UTP). The latter was erupted from the Nevado de Toluca Volcano ca. 11,600 years BP, with a silica content of 70-71%, associated with another violent Plinian type volcanic eruption.

From the point of view of timing of events that produced the palaeontological bone layer this explanation seems more plausible. Under this scenario it is possible to relate the death of the mammoths at Tocuila with the volcanic activity of Nevado de Toluca. The animal bones were incorporated in the lahar moving down a gully shortly after the eruption.

However, the bones excavated in Tocuila are well preserved showing evidence of minimal abrasion, which means that they have not been moved far, perhaps because the Tocuila site was close to the shores of Texcoco Lake where the mammoth group initially died. The Tocuila lahar is overlain by lake sediments indicating a relatively high stand of Texcoco Lake.

At other prehistoric sites like Tlapacoya there is also evidence of the presence of the PWA and UTP in situ, with associated laharic events after the deposition of each tephra marker indicating two periods of landscape instability after the deposition of the tephras. This site is important from the point of view of early human occupation of the Basin with two human skulls found in close association with the *in situ* Upper Toluca Pumice (UTP) layer. One of the skulls has been radiocarbon dated to 9730 ± 65 years BP, the first directly dated human from Mexico.

Tequexquinahuac the highest of all the studied sites, has mammoth remains (*Mammuthus columbi*) together with horse and deer. A radiocarbon date on a mammoth tusk gave a result of 13,450 ± 40 years BP (ß-153,819) with a $\delta^{13}C$ value of –16.3. The animal bones are embedded in volcanic ash, with very high values of silica of around 76-78% (Tab. 1). This indicates that they are associated with a totally different volcanic eruption and not the PWA or the UTP, because the age and the composition of the tephra does not correspond to any of the known tephra markers. It is likely that the material is coming from one of the nearby rhyolitic domes found to the SE around the Quetzaltepec Sierra (Telapón Volcano).

The Metro Man skull was found in 1970 at 3,10 mts depth during construction work for the Balderas Metro station, in the center of Mexico City. Volcanic ash samples taken from the interior of the skull gave values of silica of 70-71% associated with the UTP eruption. This has proved to be the only way of dating this skull as radiocarbon dating has not been successful due to lack of collagen preservation. This is a common problem in volcanic areas where the bones are mineralised quickly after burial.

Tab.1 - Geochemical analysis of volcanic ash (tephra shards) found in different prehistoric localities around the Basin of Mexico, either in situ or in lahar deposits.
Toc = Tocuila, Tequex= Tequexquinahuac. UTP= Upper Toluca Pumice or Tripartite Tephra. PWA= Pumice with Andesite Tephra. Mamm.= With mammoth remains.

Chemical Comp.	Tlapacoya Man Skull **UTP** In situ TC-9	Tlapacoya **PWA** In situ TA-5	Toc **UTP** In situ TocD2	Toc **PWA** In situ Toc C	Toc **UTP** Lahar Mamm.	Toc **PWA** Lahar Mamm.	Tequex **?** Mamm. Tx-4	Metro Man **UTP**
SiO_2	70.38	61.56	70.41	61.35	70.70	61.92	76.98	70.37
TiO_2	0.24	0.60	0.24	0.72	0.81	0.96	0.26	0.21
Al_2O_3	13.94	17.03	14.05	17.62	11.86	15.61	13.38	14.05
FeO	1.75	4.01	1.84	4.25	2.71	3.59	0.36	1.82
MnO	0.03	0.06	0.09	0.05	0.03	0.06	0.03	0.05
MgO	0.44	1.92	0.39	2.26	0.29	1.32	0.04	0.44
CaO	1.91	4.66	1.73	5.51	0.64	4.40	1.89	1.93
Na_2O	4.30	4.43	4.02	4.74	4.18	4.86	4.38	3.83
K_2O	2.71	2.02	2.70	1.84	3.69	1.91	2.52	2.99
Total	95.74	96.32	95.52	98.39	94.96	95.07	99.87	95.72

In conclusion there is a growing body of evidence pointing to the fact that volcanic eruptions were a very strong environmental influence in the Basin of Mexico during the Late Pleistocene. In particular the Upper Toluca Pumice layer (UTP) seems to be associated with lahars that devastated the Basin, possibly killing megafauna and humans. However these sudden processes have preserved the bones of animals and humans in volcanic deposits which help us to recreate a picture of life at the end of the Pleistocene/early Holocene in the Basin of Mexico.

The possible impact that volcanic activity had on mammoths and early humans will be discussed at the Conference, together with the questions associated with the extinction of megafauna in general (environmental stress against human presence).

REFERENCES

Bloomfield, K. & Valastro, S.Jr. 1974. Late Pleistocene eruptive history of Nevado de Toluca volcano, central Mexico. *Geological Society of America Bulletin*, 85: 901-906.

Bloomfield, K. & Valastro, S.Jr. 1977. Late Quaternary tephrochronology of Nevado de Toluca volcano, central Mexico. *Overseas Geology and Mineral Resources*, 46: 1-15.

Lorenzo, J.L. & Mirambell, L. 1986. Mamutes excavados en la Cuenca de México: Instituto Nacional de Antropología e Historia. *Cuadernos de Trabajo del Departamento de Prehistoria*, 32: 1-151.

Mooser, F. 1967. Tefracronología de la Cuenca de México para los últimos 30,000 años. *Boletín del Instituto Nacional de Antropología e Historia de México*, 30: 12-15.

Mooser, F. & González-Rul, F. 1961. Erupciones volcánicas y el hombre primitivo en la Cuenca de México. In *Homenaje a Pablo Martinez del Río en el XXV aniversario de la edición de los Origenes Americanos, Instituto Nacional de Antropología e Historia de México*: 137-141.

Mooser, F. 1997. Nueva fecha para la tefracronología de la Cuenca de México. In: *A propósito del Quaternario.* Dirección de Salvamento Arqueológico, INAH, México. Coordinación: Margarita Carballal Staedtler: 19-23.

Siebe, C., Schaaf, P. & Urrutia-Fucugauchi, J. 1999. Mammoth bones embedded in a late Pleistocene lahar from Popocatepetl Volcano, near Tocuila, central Mexico. *Geological Society of America Bulletin,* 111(10): 1550-1562.

Late Quaternary biogeography and extinction of Proboscideans in North America

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North America supported one of the highest diversities of proboscideans in one of the smallest areas during the late Pleistocene (10-20 ka). There were at least four different genera (*Mammut, Mammuthus, Haplomastodon*, and *Cuvieronius*). All of these genera were monospecific except for *Mammuthus* with four different species (*M. columbi, M. jeffersonii, M. primigenius*, and *M. exilis*). None of these proboscideans had a continental wide distribution at the end of the Pleistocene. In fact, during full glacial times when continental ice covered most of northern North America, all four proboscidean genera inhabited areas south of the ice sheet that were smaller than the geographic range of either of the living elephant genera (*Loxodonta* and *Elephas*).

Based upon geographic distribution, dental morphology, isotopic analyses, and associated paleoenvironmental indicators, all of these proboscideans probably had preferred habitats. *M. primigenius* (woolly mammoth) was the northern most taxon and it was a late Eurasian immigrant, appearing in North America some time after 200 ka. It occurred in Alaska, the upper midwestern and northeastern United States (US) and along the northern Atlantic coastal plain. The woolly mammoth preferred arctic or mammoth steppe, "tundra", and the forest/woodland ecotone between these two "biomes." *M. jeffersonii* (Jefferson's mammoth) evolved in North America and it is convergent with the woolly mammoth by having a large number of plates and thin enamel. Jefferson's mammoth occupied the upper midwestern US at the end of the Pleistocene and overlapped temporally and geographically with the woolly mammoth with which it may have been a potential competitor.

The most widespread (latitudinally, longitudinally, and altitudinally) North American proboscidean at the end of the Pleistocene was *M. columbi* (Columbian mammoth). It dominated the US west of the Mississippi River and south of the continental ice sheets. It ranged well into Mexico. The Columbian mammoth also occurred in Florida between 10-20 ka where it may have been isolated from the western populations. Columbian mammoths are known from coastal sites to more than 3000 m (10000 feet) above sea level. This species of mammoth is predominantly associated with grazing mammals like camels (*Camelops*), horses (*Equus*), bison (*Bison*), and big headed llamas (*Hemiauchenia*); it appears to have preferred a steppe/savanna/parkland environment.

Mammut americanum (American mastodont) has been in North America for at least the last five million years. During the late Pleistocene (10-20 ka), the American mastodont inhabited most of the eastern US and southeastern Canada south of the ice sheet and ranged into Mexico. Some of the richest and latest finds of *Mammut* occur in the Great Lakes region of the US and Canada, the Mississippi River valley, and Florida. There are a few isolated terminal Pleistocene records in the western US. Its distribution is almost a mirror image of the distribution of the Columbian mammoth. Also, in well-stratified sites in the midwestern US, mammoth and American mastodont almost never co-occur at a site suggesting habitat exclusion. The American mastodont preferred woodland to forest habitats, especially the late Pleistocene boreal forest. It is frequently found with browsing mammals like giant beaver (Castoroides), stagmoose (*Cervalces*), woodland musk ox (*Bootherium*), and stout-legged llama (*Palaeolama*).

Haplomastodon and *Cuvieronius* are two New World genera with pre-Quaternary origins in North America but they primarily inhabited southern North America, Central America, and South America during the late Quaternary. At the end of the Pleistocene, *Haplomastodon* and *Cuvieronius* only extended as far north as Mexico. There may have been an isolated population of *Cuvieronius* in Florida. These two mastodonts were geographically sympatric with *Mammut* and *Mammuthus* in central Mexico in the terminal Pleistocene, although their temporal and ecological overlaps are poorly known. The molar teeth of *Haplomastodon* and *Cuvieronius* have similar morphology and they both presumably preferred open woodland habitat as well as mesic tropical lowland habitats farther to the south.

Mammuthus exilis had the smallest geographic distribution of any of the North American proboscideans as it was restricted to the Channel Islands off the coast of California. It was presumably derived from the Columbian mammoth.

All of these proboscideans became extinct sometime after the last glacial maximum (18 ka) and it appears that most, if not all, survived until the terminal Pleistocene (10-12 ka). Extensive dating of *M. columbi* and *M. americanum* remains indicate that both of these taxa survived until 10.8 ka while most other large Pleistocene mammals were extinct by 11 ka. These data suggest that the Keystone Species Model of Pleistocene extinction may not be valid for these taxa since they were the last, rather than the first, to go extinct. These dates are concordant with a Clovis model of extinction but they are also in agreement with a major climate trigger, the Younger Dryas.

Several factors probably contributed to proboscidean extinction and these same factors are critical to the survival of modern elephants. Geographic range reduction was probably the dominant factor. The pre-Wisconsin distribution for all North American proboscideans, except for *M. exilis*, demonstrates that their ranges were reduced throughout the Quaternary. Among mammals in general, it is believed that the probability of extinction increases exponentially with reduction in geographic range. Futhermore, the size of the home range of a mammal species is a direct function of its body size. As the largest ungulates, proboscideans would have required the largest geographic ranges. As already documented, the inclusive geographic range of all of these proboscideans during the late Quaternary was less than the range of either of the living elephant species historically.

Habitat destruction was probably another contributing factor. The Pleistocene proboscideans had preferred habitats as documented by their geographic ranges, dental morphology, isotopic composition of their tooth enamel, and association with other environmental proxies. The extinction of proboscideans and other megafauna is highly correlated with the disappearance of certain Pleistocene habitat types (open boreal forest, parkland, and savanna).

One of the challenges for environmental models of extinction is the question: What was unique about the end of the Pleistocene environmental change? If geographic range reduction was one of the major drivers, as proposed here, then the environmental change does not need to be unique but must simply serve as a trigger once a threshold has been reached. For geographic range reduction, the threshold is critical minimum population size or critical minimum size for geographic range. Until these limits are reached, environmental change will not cause extinction but once these limits are exceeded then extinction will be triggered.

The environmental change does not need to be unique but merely drive populations and geographic ranges below viable limits.

Human involvement in proboscidean extinction in North America is hard to evaluate. Evidence for human association with late Quaternary North American proboscideans has only been found for *M. columbi, M. americanum*, and *Haplomastodon*. In these cases, humans may have been involved in their demise. However, the actual impact of humans is not really known because it is hard to estimate predation pressure and population sizes for proboscideans and humans.

Finally, the extinction of North American late Quaternary proboscideans underscores the significance of geographic range and habitat for the survival of the modern elephant species.

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Ancient elephants of West Siberia

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SUMMARY: In the territory of West Siberia, including the Ural Mountain region, there are more than 250 sites with Plio-Pleistocene elephant remains. An inventory of sites and of identified taxa is given below, together with the geografical distribution.

1. SITES AND TAPHONOMY

In the territory of West Siberia, including the Ural Mountain region, there are more than 250 sites with Plio-Pleistocene elephant remains. Overall, these sites can be grouped into three main types: (i) alluvial sites, (ii) caves and (iii) archaeological sites. Skeletal materials recovered from these sites are primarily post-cranial elements and various fragmented parts. Loose teeth usually occur only in small quantities and complete mandibles are very rare. Thirteen complete and partial skeletons (excluding those found at archaeological sites), one mummified corpse, and one frozen carcass have been recovered from alluvial sites.

1.1 Alluvial Sites

There are more than two hundred such sites situated within the plain area of West Siberia. The ages of these sites date from the Late Pliocene to the end of the Late Pleistocene. The amount of bones recovered from these areas is quite variable and ranges from one to a few thousand. Two depositional sites are known where the quantity of mammoth remains recovered represents several thousand bones and more than ten individuals. The degree of preservation of the skeletal remains also varies from fragmentary to complete skeletons. A substantial number of these bones have been found in disturbed contexts, while some have been found *in situ*.

1.2 Caves

There are twenty such sites situated in the mountainous area of the Urals. The age of all of the sites falls within the middle of the second half of the Late Pleistocene. The quantity of bones recovered from one site can range from one to a few hundred. The degree of preservation of the bones ranges from fragmentary to whole individual elements. All bones were found *in situ*.

1.3 Archaeological Sites

There have been ten such sites found that have contained mammoth bones. The ages of these sites range from the Mousterian period (one site) to the Upper Paleolithic (nine sites). The archaeological sites are represented by two main types: (i) caves and (ii) open sites. From the settlements associated with grottos a few bones have been recovered, while complete mammoth skeletons have been recovered from the open sites. The number of skeletons ranges from one to more than ten at some sites and all skeletal elements were found *in situ*. All settlements found within open locations are thought to represent sites utilized for the butchery of mammoth carcasses. It is possible that the mammoths found there died of natural causes.

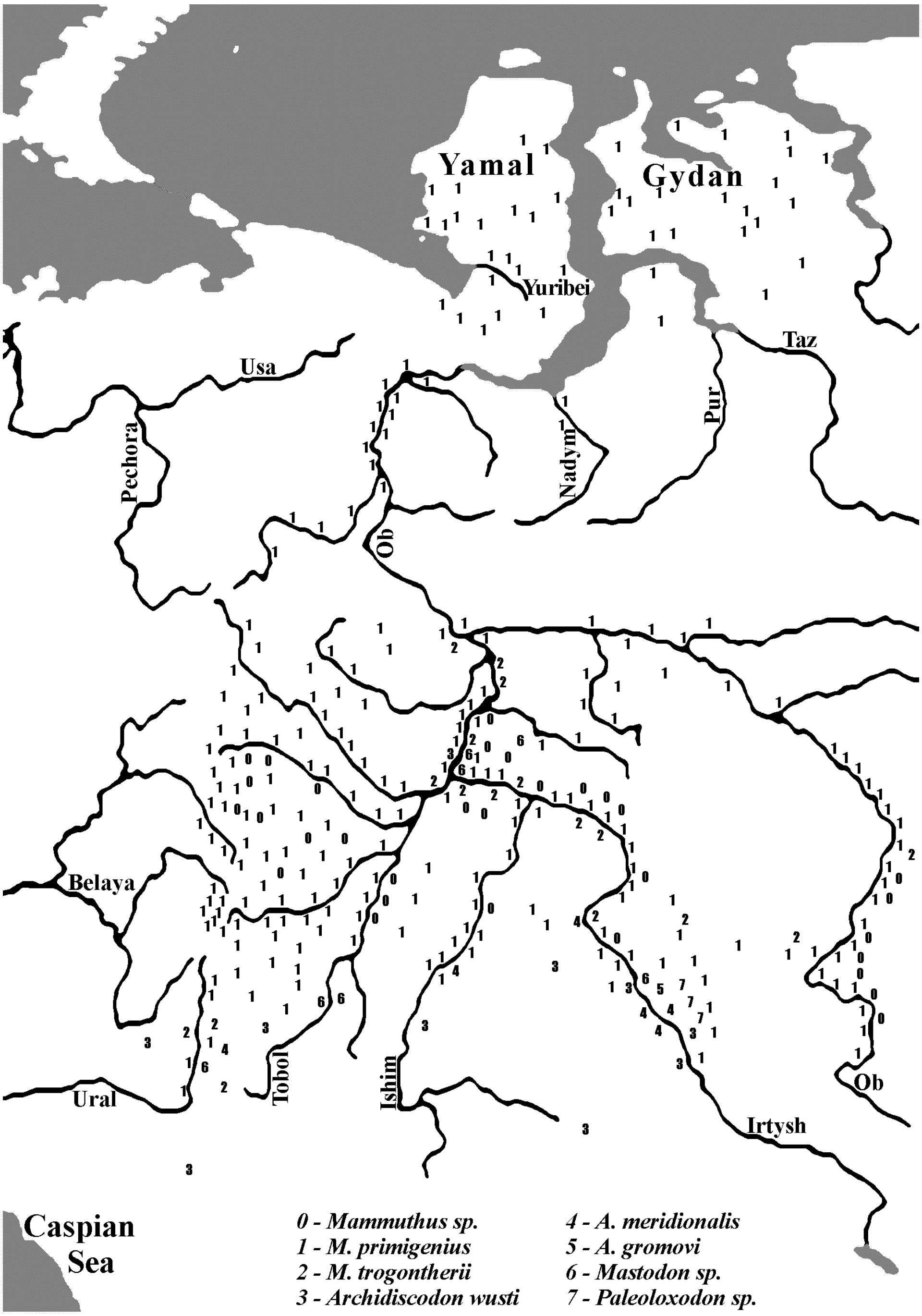

Fig.1 - Distribution map of sites with Plio-Pleistocene elephant remains from West Siberia and the Ural Mountain Region, with an indication of the number of identified taxa.

2. Species representation

Palaeoloxodon sp.:

There are a few loose teeth (Zhylkibaev 1975) recovered from three alluvial sites (Fig. 1).

Archidiskodon gromovi Garutt & Alexeeva 1965:

There is one find (Zhylkibaev 1975) recovered from an alluvial site (Fig. 1).

Archidiskodon meridionalis (Nesti 1825):

There are four sites (all alluvial) where finds of this species have been recovered (Fig. 1), representing loose teeth and a partial skeleton (Zhylkibaev 1975; Yahimovich 1965).

Mammut borsoni (?) (Hays 1934):

There have been a number of loose teeth recovered from six alluvial sites (Kozhamkulova & Kostenko 1984; Yahimovich 1965). Teeth from three northern sites (Fig. 1) have been recovered from mixed contexts associated with river activity.

Mammuthus trogontherii (Pohlig 1885):

There have been 3 partial skeletons, 3 mandibles and more than 20 loose teeth and bones from the post-cranial skeleton (Vangengeim & Sher 1972; Zhylkibaev 1975; Borodin *et al.* 1998; Shpanskii 2000; Yahimovich 1965) recovered from twelve alluvial sites (Fig. 1).

Mammuthus primigenius (Blumenbach, 1799):

There are 9 partial and complete skeletons, more than 10 mandibles, more than 100 loose teeth and more than 10,000 post-cranial skeletal bones recovered from alluvial sites. There are 3 mandibles, 10 loose teeth and more than 400 post-cranial skeletal bones recovered from caves and grottos. There are more than 10 complete and partial skeletons, a few loose teeth and more than 1000 post-cranial skeletal bones recovered from settlement sites. The bones recovered represent individuals of all age categories, from embryos to advanced old age. In addition, tooth remains have been recovered that represent all evolutionary stages of this species from early to late forms.

Two depositional areas are known where more than just skeletal material has been recovered. One site contained the mummified remains of a mammoth and the other site a frozen carcass. The settlement sites are situated in West Siberia and in the Ural Mountain region.

Mammuthus sp.:

There are a few separate teeth from twenty alluvial sites situated south of 61° N. The structure of these teeth is intermediate between *M. trogontherii* and *M. primigenius* (possibly referable to *Mammuthus chosaricus*, Dubrovo 1966).

3. Distribution of taxa

M. primigenius was distributed over the entire territory of West Siberia and the Ural Mountain region. Bones of the most ancient species (*M. trogontherii* and geus *Archidiskodon*) have been found only south of 61° N. This situation results from the fact that north of 61° N the early Middle Pleistocene (Q_I-Q_{II}) deposits are, with rare exceptions, deeply buried under late Pleistocene (Q_{III}) deposits. However, south of 61° N, early Middle Pleistocene (Q_I-Q_{II}) and Pliocene deposits are exposed on the surface at many sites. In this way the distribution of proboscidean finds is very much controlled by the particular geological features of West Siberia.

4. Evolution and extinction

In West Siberia, south of 61° N, the remains of all species of the evolutionary line *Archidiskodon-Mammuthus* have been found. This situation makes it possible to speak of an unbroken evolutionary line for this particular group of elephants. In the south of West Siberia are found the remains of another evolutionary line of elephants, which is related to *Palaeoloxodon* and parallels the *Archidiskodon-Mammuthus* lineage.

Twenty-nine radiocarbon dates (Sulerzhitskii 1995; Sokolov 1982) have been undertaken on mammoth bones recovered from West Siberia and twelve radiocarbon dates have been provided on bones from other species. Two of the mammoth samples gave a date of 50,000 BP, while the others lie within the interval 41,900 BP to 9600 BP. Analysis of the geographical distribution of the dates shows that in West Siberia the area occupied by mammoth decreased from south to north. Most of the latest dates (10,350±50 BP; 10,000±70 BP; 9730±100 BP; 9600±300 BP) are from the northern part of West Siberia (Yamal Peninsula and Gydan Peninsula). Therefore, it appears that mammoth became extinct in West Siberia at approximately 10,000 BP.

5. MAMMOTH AND HUMAN INTERACTION

Mammoth bones have been found in three archaeological cave sites. Two such sites have yielded a few mammoth bones, while a third site has produced many bones from one individual (Kuzmina 1975). On the basis of indirect data (i.e. geology and geomorphology), one may suggest that this particular individual died of natural causes and was subsequently butchered by humans.

Two more archaeological sites are situated at mammoth bone deposition areas related to river activity. At six sites that contain faunal materials, mammoth bones are not present. This fact suggests that ancient humans in West Siberia and the Ural Mountain region rarely hunted mammoths, however they utilized mammoth carcasses as a food resource.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Borodin, A.V., Kosintsev, P.A., Zinoviev, E.V., Trofimova, S.S., Nekrasov, A.E. 1998. Palaeoecological investigations of the landscape inhabited by the early Middle Pleistocene mammoth Archidiskodon trogontherii from Chembakchino, Western Siberia. *Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO*. 60: 343-352.

Kozhamkulova, B.S. & Kostenko, N.N. 1984. *Extinct Animals of Kazakhstan*. Alma-Ata: Nauka.

Kuzmina, I.E. 1975. Some Data Concerning Mammals of the Middle Ural in the Upper Pleistocene. In V.I. Gromov & I.K. Ivanova (eds.), *Bulletin of the Commission for Research of the Quaternary Period*, 43: 63-77. Moscow: Nauka.

Shpanskii, A.V. 2000. Ungulates of the Middle-Late Neo-Pleistocene of the Southeast Region of the West Siberian Plain (Stratigraphic Significance, Palaeoecology and Palaeozoogeography). Ph.D. Dissertation, Tomsk State University. Unpublished.

Sokolov, V.E. (ed.) 1982. *Yuribeisky mamoth*. Moscow: Nauka.

Sulerzhitskii, L.D. 1995. Characteristics of Radiocarbon Chronology of the Woolly Mammoth (*Mammuthus primigenius*) of Siberia and north of Eastern Europe. In G.F. Barishnikov (ed.), *Investigation of Pleistocene and Recent Mammals*, 263: 163-183.

Vangengeim, E.A. & Sher, A.V. 1972. Siberian Equivalents of the Tiraspol faunal complex. In I.K. Ivanova & N.A. Konstantinova (eds.), *Geography and Fauna of the Lower and Middle Pleistocene of Europe*: 245-255. Moscow: Nauka.

Yahimovich, V.L. (ed.) 1965. *Anthropogen of the South Ural*. Moscow: Nauka.

Zhylkibaev, K.Zh. 1975. *Ancient Elephants of Kazakhstan*. Alma-Ata: Nauka.

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Human-mammoth (*Mammuthus primigenius* Blumenbach) inter-relationships in the Palaeolithic of Siberia: a review of current knowledge

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Spatial-temporal features of human-mammoth interaction in Siberia are being reconstructed using archaeological, palaeontological, and radiocarbon (^{14}C) data (*cf.* Tseitlin 1979; Derevianko, 1998; Kuzmin & Orlova 1998; Orlova *et al.*, 2000a, 2000b, *etc.*). Only sites with ^{14}C age control are considered in this study. For the time interval *ca*. 18,000-12,000 BP, we selected 54 Upper Paleolithic sites (with 160 ^{14}C dates) and 30 mammoth localities (with 60 ^{14}C dates) (Orlova *et al.* 2000b) (Fig. 1). The sites are distributed across Siberia and the Russian Far East. The mammoth sites include several with mass accumulations of mammoth bones ("cemeteries"), close to Palaeolithic sites. Of these, the best-studied in terms of archaeology and palaeontology are Berelekh, Shestakovo, and Volchya Griva.

Berelekh (latitude 70°26' N, longitude 143°57′ E), near the coast of the Arctic Ocean; has yielded numerous mammoth bones (from at least 140 individuals; Vereshchagin, Baryshnikov, 1982, 1984). A Palaeolithic site lies only a few hundred metres away (Mochanov & Fedoseeva, 1996). ^{14}C dates on mammoth remains range from *ca*. 13,700 BP to *ca.* 10,400 BP, while ^{14}C dates on wood from the nearby archaeological site are between *ca.* 13,400 BP and *ca.* 10,600 BP. Mammoth tusks were used as raw material for making knives, spears, and scrapers, and some mammoth bones had been burned.

Shestakovo (55°54′ N, 87°57′ E), in south-western Siberia, contains a mass accumulation of mammoth remains in Palaeolithic cultural layers (Derevianko *et al.* 2000; Zenin *et al.* 2000a). Many of the mammoth bones are burnt. ^{14}C dates range from *ca.* 25,700 BP to *ca.* 18,000 BP (mammoth bones); *ca*. 24,600 BP to *ca.* 20,400 BP (horse and reindeer bones), and *ca.* 23,300 BP to *ca.* 20,800 BP (charcoal) (Derevianko *et al.* 2000; Zenin *et al.* 2000b). The variation in the dates suggests that humans scavenged sub-fossil mammoth bones, and used them for various purposes, such as tool making (including needles, awls, and anthropomorphic figurines) and also for fuel (Zenin *et al.* 2000a: 749-750). Both human and carnivore modification was observed on bones of various species. Taphonomic analysis makes it possible to identify significant contrasts in the degree of surface weathering between mammoth and other animal bones. In general, the mammoth bones are heavily weathered and very fragmentary, indicating that they had experienced a prolonged period of subaerial exposure.

Only a small proportion of these bones preserve clear carnivore marks. Much more of the mammoth material shows clear evidence of human modification, including burning, cut-

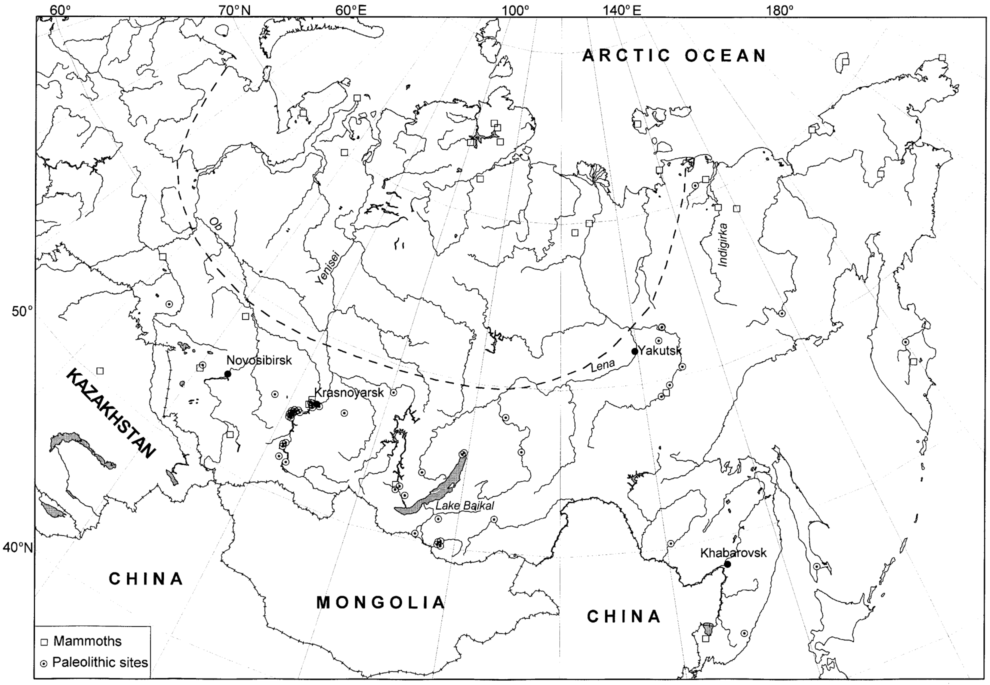

Fig.1 - Radiocarbon-dated mammoths and Paleolithic sites in Northern Asia, 18,000-12,000 BP.

marks, percussion damage, and painting with red pigment. In contrast, the better surface preservation seen in material of other mammalian species (rhinoceros, horse, and reindeer) indicates much shorter surface exposure. It seems that the Shestakovo Palaeolithic humans may have scavenged mammoth bones from a nearby natural surface accumulation close to salt licks (Derevianko *et al.* 2000). Bones of other animals at this site were probably transported to the site from kills made elsewhere by human hunters.

Volchya Griva (*Wolf's Ridge*) (54°39′ N, 80°15′ E), also in southwestern Siberia, is an example of mammoth “cemetery”, with a few stone tools and modified bones, including some that had been split, or polished, or painted with red pigment. ^{14}C mammoth dates range from *ca.* 14,800 BP to *ca.* 11,100 BP (Orlova *et al.* this volume). Palaeolithic humans re-distributed mammoth bones in the site area, and created several spots with high bone concentration; however, no traces of artificial dwellings were found.

To model human-mammoth interaction, we choose the time interval *ca.* 18,000-12,000 BP. ^{14}C-dated Paleolithic sites provide the most reliable evidence of human settling of the territory. From 18,000-12,000 BP, mammoth existed throughout Siberia and adjacent regions of Kazakhstan and Northeastern China (Fig. 1). From *ca.* 40,000 BP human groups gradually moved north from southern Siberia (Kuzmin, Tankersley, 1996; Orlova *et al.*, 2000a: 35). At *ca.* 24,000 BP, people had reached central Yakutia (Dyuktai culture; Kuzmin, Orlova, 1998: 35-39). After *ca.* 18,000 BP, several human groups migrated eastwards, and at *ca.* 14,000-13,300 BP colonized the interior Kolyma River basin (Siberdik site) and the Kamchatka Peninsula (Ushki group of sites). By *ca.* 12,300 BP, humans had reached the coast of the Arctic Ocean (Berelekh) (Kuzmin & Orlova 1998: 41-45; Goebel & Slobodin 1999). Thus, at *ca.* 12,000 BP only the northern parts of both Western and Eastern Siberia lay outside the northern limit of Palaeolithic occupation (dashed line on Fig. 1).

Analysis of the distribution of mammoths and humans in Siberia *ca.* 18,000-12,000 BP demonstrates that in several regions both coexisted for a long period of time. Although the area occupied by humans expanded from ca. 24,000 BP (Orlova *et al.* 2000: 33-35), mammoths continued to exist within the regions newly inhabited and explored by humans. This situation is evidenced not only by the presence of ^{14}C-dated mammoths and prehistoric sites in the same area (Fig. 1), but also the finding of mammoth bones, tusks, and teeth in the Upper Palaeolithic cultural layers. One of the most representative areas is in the middle part of the Yenisei River, southwest of Krasnoyarsk (Fig. 1), where a large proportion of Palaeolithic sites contains mammoth bones (at least 12 ^{14}C-dated sites) (Tseitlin 1979; Abramova *et al.* 1991; Derevianko *et al.* 1992; Lisitsyn 2000). In this area, the ^{14}C age of sites with mammoth bones ranges from *ca.* 24,900 BP to *ca.* 12,100 BP (bone and charcoal dates); with ^{14}C dates on mammoth material of *ca.* 20,100 BP to *ca.* 13,400 BP. So a 13,000 year overlap in human and mammoth presence did not result in extinction (and/or migration) of the latter.

Undoubtedly, mammoths were subject to human hunting, though it is difficult to assess the significance of this in the prehistoric economy. We note that human expansion in Siberia from *ca.* 24,000 BP, and especially across Northeastern Siberia after *ca.* 18,000 BP, did not cause a marked reduction of mammoth distribution. The drastic shrinkage of mammoth range occurred from *ca.* 12,000 BP (Sulerzhitsky 1997; Sher 1997; Kuzmin *et al.* 2000), both within and beyond the area occupied by Palaeolithic people. Thus, we have no evidence to suggest that human hunting pressure had a significant, effect on Siberian mammoth populations.

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REFERENCES

Abramova, Z.A., Astakhov, S.N., Vasiliev, S.A., Ermolova, N.M. & Lisitsyn, N.F. 1991. *Paleolithic of the Yenisei*. Leningrad: Nauka (in Russian).

Derevianko, A.P. (ed.) 1998. *The Paleolithic of Siberia: New Discoveries and Interpretations*. Urbana and Chicago: University of Illinois Press.

Derevianko, A.P., Drozdov, N.I. & Chekha, V. P. (eds.) 1992. *Archaeology, geology, and paleogeography of the Paleolithic sites in southern Middle Siberia*. Krasnoyarsk: Institute of Archaeology and Ethnography (in Russian).

Derevianko, A.P., Zenin, V.N., Leshchinsky, S.V. & Mashchenko, E.N. 2000. Peculiarities of mammoth accumulation at Shestakovo site in West Siberia. *Archaeology, Ethnology, and Anthropology of Eurasia* 1 (3): 42-55.

Goebel, T. & Slobodin, S.B. 1999. The colonization of Western Beringia: Technology, ecology, and adaptations. In R. Bonnichsen & K.L. Turnmire (eds.) *Ice Age peoples of North America: Environments, origins, and adaptations*: 104-155. Corvallis: Oregon State University Press.

Kuzmin, Y.V. & Orlova, L.A. 1998. Radiocarbon chronology of the Siberian Paleolithic. *Journal of World Prehistory,* 12 (1): 1-53.

Kuzmin, Y.V., Orlova, L.A., Zolnikov, I.D. & Igolnikov, A.E. 2000. The history of mammoth (Mammuthus primigenius Blum.) population in Siberia and adjacent areas (based on radiocarbon data). *Russian Geology and Geophysics,* 41 (5): 746-754 (in Russian).

Kuzmin, Y.V. & Tankersley, K.B. 1996. The colonization of Eastern Siberia: An evaluation of the Paleolithic age radiocarbon dates. *Journal of Archaeological Science,* 23 (4): 577-585.

Lisitsyn, N.F. 2000. *The Late Paleolithic of Chulym-Yenisei region*. St.-Petersburg: Center “Petersburg Oriental Studies” (in Russian).

Mochanov, Y.A. & Fedoseeva, S.V. 1996. Berelekh, Allakhovsk Region. In F.H. West (ed.), *American beginnings: The prehistory and palaeoecology of Beringia*: 218-221. Chicago: University of Chicago Press.

Orlova, L.A., Kuzmin, Y.V, & Zolnikov, I.D. 2000a. Time-space systematics for mammoth (*Mammuthus primigenius* Blum.) and prehistoric humans in Siberia (on the basis of radiocarbon dating). *Archaeology, Ethnology, and Anthropology of Eurasia* 1 (3): 31-41.

Orlova, L.A., Kuzmin, Y.V., Volkova, V.S. & Zolnikov, I.D. 2000b. Mammoth (*Mammuthus primigenius* Blum.) and prehistoric humans in Siberia: mutual analysis of populations based on radiocarbon data. In S.V. Markin (ed.) *Problems of the reconstruction of climate and environment of the Holocene and Pleistocene in Siberia,* 2: 383-412. Novosibirsk: Institute of Archaeology and Ethnography Press (in Russian).

Sher, A.V. 1997. Late-Quaternary extinction of large mammals in northern Eurasia: A new look at the Siberian contribution. In B. Huntley, W. Cramer., A. V. Morgan, H. C. Prentice & J. R. M. Allen. (eds.) *Past and future rapid environmental changes: The spatial and evolutionary responses of terrestrial biota*: 319-339. Berlin-Heidelberg-New York: Springer-Verlag.

Sulerzhitsky, L.D. 1997. Patterns of the radiocarbon chronology of mammoths in Siberia and northern Eastern Europe (as sub-stratum for human dispersal). In A.A. Velichko & O. Soffer (eds.), *Humans settlement the Planet Earth*: 184-202. Moscow: Institute of Geography. (in Russian).

Tseitlin, S.M. 1979. *Geology of the Paleolithic of Northern Asia*. Moscow: Nauka (in Russian).

Vereshchagin, N.K. & Baryshnikov, G.F. 1982. Paleoecology of the mammoth fauna in the Eurasian Arctic. In D. M. Hopkins, J. V. Matthews Jr., C.E. Schweger & S.B. Young (eds.) *Paleoecology of Beringia*: 267-279. New York: Academic Press.

Vereshchagin, N.K. & Baryshnikov, G.F. 1984. Quaternary mammalian extinctions in Northern Eurasia. In P.S. Martin & R.G. Klein (eds.) *Quaternary extinctions: A prehistoric revolution*: 483-516. Tucson: University of Arizona Press.

Zenin, V.N., van der Plicht, J., Orlova, L.A., Kuzmin, Y.V. & Brantingham, P.J. 2000a. Geoarchaeology of the Shestakovo Upper Paleolithic site, Western Siberia: Human-mammoth interactions during the Last Glacial Maximum. *Current Research in the Pleistocene*, 17: 103-105.

Zenin, V.N., van der Plicht, J., Orlova, L.A. & Kuzmin, Y.V. 2000b. AMS ^{14}C chronology of woolly mammoth (*Mammuthus primigenius* Blum.) remains from the Shestakovo Upper Paleolithic site, Western Siberia: Timing of human-mammoth interaction. *Nuclear Instruments and Methods in Physics Research* (Section B), 172: 745-750.

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Chronology and environment of woolly mammoth (*Mammuthus primigenius* Blumenbach) extinction in northern Asia

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Over the past decade radiocarbon (^{14}C) dating has allowed us to reconstruct patterns of latest survival of woolly mammoth in Northern Asia (Stuart 1991; Sulerzhitsky 1997; Vasil'chuk *et al.* 1997; Orlova *et al.* 2000). At present, we have about 360 ^{14}C dates from 150 localities, including: Siberia and adjacent territories of the Russian Far East; Kazakhstan; and northeastern China. Although it is possible that additional information may alter the current picture, the substantial body of data that we now have allows us to reconstruct the dynamics of mammoth extinction in Northern Asia with a reasonably high degree of confidence.

The data available at the beginning of 2000, show that prior to *ca.* 12,000 ^{14}C years ago (BP) mammoths were present throughout almost all of Northern Asia. Within the period ca. 15,000-12,000 BP, ^{14}C-dated mammoth remains (40 dates) are known from the eastern Chukotka Peninsula (longitude 170° W) as far as the Irtysh River in Western Siberia (69° E); and from the Taymyr Peninsula and Kotel'nyy Island (latitude 75-76° N) to Volchya Griva in Western Siberia (55° N), Sosnovy Bor in Eastern Siberia (53° N), and Khorol and Xiaonanshan in the Far East (44-47° N).

After *ca.* 12,000 BP, the range of mammoths was significantly reduced (Fig. 1). Until recently, mammoth remains with ^{14}C-dates younger than this (13 dates) were available only for the High Arctic, north of 69° N. However, in 2000, the additional ^{14}C dates were obtained from the Volchya Griva locality (54°30′ N, 80°12 E′) in the Barabinskaya steppe of the southern West Siberian Lowland, 175 km west of Novosibirsk (Fig. 1). These are: 11,090±120 BP (SOAN-4291), from 1.24 m below the surface; 12,520±150 BP (SOAN-4293), 1.30-1.35 m; and 14,280±285 BP (SOAN-4292), 1.44 m. Collagen for dating was extracted using cold HCl solution (Sulerzhitsky, 1997: 185-187; Kuzmin & Orlova, 1998: 3-5). It is clear that the youngest date, SOAN-4291, is likely to be correct as it is in good agreement with the site stratigraphy, suggesting survival of mammoths in southwestern Siberia until *ca.* 11,000 BP. This suggestion needs to be confirmed by additional data. Previous ^{14}C dates for the Volchya Griva range from *ca.* 14,800 BP to *ca.* 13,600 BP (Orlova 1990; Orlova *et al*. 2000).

At the Berelekh River locality, most of the ^{14}C dates are within the period *ca.* 13,700-12,000 BP. However, a later date of *ca.* 10,400 BP was obtained (on a thoracic vertebra) from the 2nd (10-12 m) terrace deposits (Orlova, 1979). In addition, three ^{14}C dates were obtained on the same individual mammoth from the Yuribei River: 9600±300 BP (VSEG-INGEO); 9730±100 BP (MGU-763); and 10,000±70 (LU-1153) (Sokolov 1982). In view of the pretreatment procedures used (L. D. Sulerzhitsky, pers. comm. 2001) the LU-1153 value has been accepted as the most reliable-whereas the VSEGINGEO and MGU-763 values were discarded (Sulerzhitsky, 1997: 197).

A chronology of mammoth extinction in Siberia, based on currently available evidence, is presented in table 1. During *ca.* 14,800-11,100 BP, mammoth survived in southern West Siberia in association with steppe environments on the watersheds, and with birch and spruce forests in the river valleys (Orlova 1990). However, after *ca.* 11,000 BP, they were restricted to the High Arctic, where the latest known ^{14}C dates come from the Taymyr Peninsula (Fig. 1).

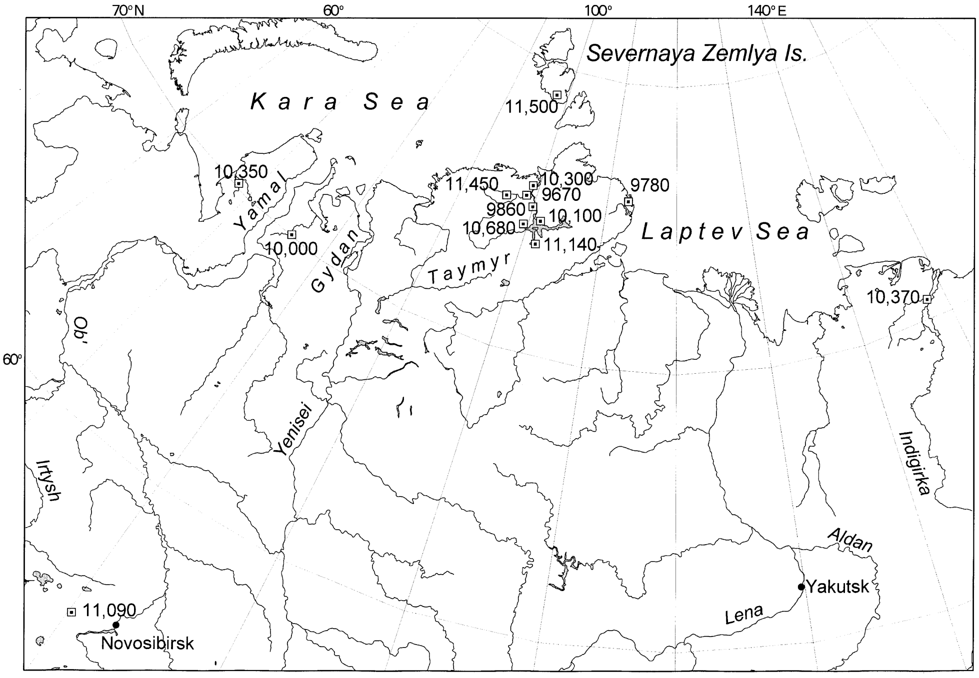

Fig.1 - Latest radiocarbon-dated mammoths in northern Asia (11,500-9,670 BP)

Tab.1 - ^{14}C age of the latest mammoths in Siberia (12,000-9700 BP)

Location	^{14}C age, BP (±1σ)	Lab No.	Calendar age, cal BP (±2σ)
Nizhnaya Taymyra River (Taymyr Pen.)	9670±60	GIN-1828	11,260-10,600
Andrei Polar Station (NE Taymyr Pen.)	9780±40	GIN-8256	11,330-10,890
Nizhnaya Taymyra River	9860±50	GIN-1495	11,630-11,120
Yuribei River (Gydan Pen.)	10,000±70	LU-1153	12,290-11,170
Engel'gardt Lake (Taymyr)	10,100±100	GIN-1489	12,780-11,170
Nizhnaya Taymyra River	10,300±100	GIN-1828k	12,890-11,230
Mutnaya Seyakha River (Yamal Pen.)	10,350±50	GIN-6386	12,830-11,700
Berelekh River (Northeast Siberia)	10,370±70	SOAN-372	12,880-11,580
Nganasanskaya River (Taymyr)	10,680±70	GIN-3768	13,000-12,170
Volchya Griva (West Siberia)	11,090±120	SOAN-4921	13,780-12,640
Baykuraneru Bay, Taymyr Lake	11,140±180	GIN-3067	13,850-12,340
Mamonta River (Taymyr)	11,450±250	T-297	15,300-12,350
Oktyabrs'koy Revolyutsii Is. (Arctic)	11,500±60	LU-610	13,840-13,150
Berelekh River	12,000±130	LU-149	15,410-13,430

Using the CALIB 4.3 calibration program (Stuiver *et al.* 1998), we obtained calendar ages for the youngest ^{14}C mammoth dates (Tab. 1). The latest mammoths in West Siberia date from *ca.* 13,800-12,600 cal BP; *ca.* 12,900-11,600 cal BP in the Berelekh River basin; *ca.* 12,800-11,700 cal BP in the Yamal Peninsula; *ca.* 12,300-11,200 cal BP in the Gydan Peninsula; and *ca.* 11,300-10,600 cal BP in the Taymyr Peninsula

It seems clear that the Taymyr Peninsula was the last mainland refugium for mammoths in Northern Asia. Palaeoenvironmental studies in Taymyr show that in the Younger Dryas, *ca.* 10,900 BP, tundra with shrub birch was the prevailing vegetation (Bardeeva *et al.* 1980; Muratova *et al.* 1993). At the Younger Dryas/Holocene boundary, *ca.* 10,000 BP, and in the Preboreal period, *ca.* 9300-9100 BP, tree cover increased and the main vegetation type became forest-tundra with spruce, pine, larch, and tree birch (Kind 1974; Bardeeva *et al.* 1980). About 10,500 BP, larch (*Larix sibirica*) appeared in the Novaya River basin (72°35′ N) (Ukraintseva 1990), and today this is the most northerly occurrence of trees in the Arctic Ary-Mas forest massif. At the beginning of the Holocene, the northern limit of larch was north of the Novaya River (Ukraintseva 1990).

From evidence of the environmental conditions in most of Siberia during the Late Glacial, *ca.* 15,000-10,000 BP, it appears that mammoths lived in a landscape of tundra and forest-tundra (cf., Lozhkin 1998). The increase of tree species in the vegetation cover, which began at *ca.* 12,500-12,000 BP (e.g., Lozhkin 1993; Sher 1997), corresponds with a marked decrease in mammoth distribution.

Future work on mammoth extinction should include a search for the latest mammoths (i.e., less than *ca.* 13,000 BP) in southern Siberia. From existing ^{14}C data (e.g., Kuzmin & Orlova 1998), we suspect that several Siberian sites might yield post-13,000 BP mammoth remains: Volchya Griva in Western Siberia; and several Upper Paleolithic sites in Eastern Siberia, e.g. Afontova Gora 1 and 3 (Astakhov 1999), Kokorevo 2 (Tseitlin 1979: 111-112), Listvenka (Derevianko *et al.* 1992: 34-48; Drozdov *et al.* 1999: 149), and Bolshaya Slizneva (Derevianko *et al.* 1992: 22-34). Additional work is also needed in the Taymyr Peninsula, primarily in the Taymyr Lake area.

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REFERENCES

Astakhov, S.N. 1999. *Paleolithic of the Yenisei: Paleolithic sites on the Afontova Gora in the Krasnoyarsk.* St.-Petersburg: European House (in Russian).

Bardeeva, M.A., Isaeva, L.L., Andreeva, S.M., Kind, N.V., Nikolskaya, M.V., Pirumova L.G., Sulerzhitsky, L.D. & Cherkasova, M.N. 1980. Stratigraphy, geochronology, and paleogeography of the Late Pleistocene and Holocene of the northern Middle-Siberian Plateau. In I. K Ivanova. & N.V. Kind (eds.), *Geochronology of the Quaternary*: 198-207. Moscow: Nauka (in Russian).

Derevianko, A.P., Drozdov, N.I. & Chekha, V.P. (eds.) 1992. *Archaeology, geology, and paleogeography of the Paleolithic sites in southern Middle Siberia.* Krasnoyarsk: Institute of Archaeology and Ethnography (in Russian).

Drozdov, N.I., Chlachula, J. & Chekha, V.P. 1999. Pleistocene environments and Paleolithic occupation of the northern Minusinsk Basin, southern Krasnoyarsk Region. *Antropozoikum* 23: 141-155.

Kind, N.V. 1974. *Geochronology of the Late Anthropogene by isotopic data*. Moscow: Nauka (in Russian).

Kuzmin, Y.V. & Orlova, L.A. 1998. Radiocarbon chronology of the Siberian Paleolithic. *Journal of World Prehistory* 12 (1): 1-53.

Lozhkin, A.V. 1993. Geochronology of Late

Quaternary events in Northeastern Russia. *Radiocarbon* 35 (3): 429-433.

Lozhkin, A.V. 1998. About the ^{14}C dating and palynological characteristic of the mammoth burial ground on the Berelekh River in the Indigirka lowerstream. In K. V. Simakov (ed.), *Changes of the Beringia environment in Quaternary:* 45-62. Magadan: Northeastern Complex Research Institute (in Russian).

Muratova, M.V., Serebryanny, L.R., Denisenko, O.V. & Kiselev, S.V. 1993. Climate and vegetation changes in the Northern Eurasia during the Younger Dryas. *Geographica Helvetica* 48 (3): 111-119.

Orlova, L.A. 1979. Radiocarbon age of the fossil mammoth remains on the USSR territory. *Bulletin of the Siberian Branch of the USSR Academy of Sciences. Social Science, Series* 16 (2): 89-97 (in Russian).

Orlova, L.A. 1990. *The Holocene of the Barabinskaya steppe (stratigraphy and radiocarbon chronology)*. Novosibirsk: Nauka (in Russian).

Orlova, L.A., Kuzmin, Y.V. & Zolnikov, I.D. 2000. Time-space systematics for mammoth (*Mammuthus primigenius* Blum.) and prehistoric humans in Siberia (on the basis of radiocarbon dating). *Archaeology, Ethnology, and Anthropology of Eurasia* 1 (3): 31- 41.

Sher, A.V. 1997. Late-Quaternary extinction of large mammals in northern Eurasia: A new look at the Siberian contribution. In B. Huntley, W. Cramer., A. V. Morgan, H. C. Prentice & J. R. M. Allen. (eds.), *Past and future rapid environmental changes: The spatial and evolutionary responses of terrestrial biota*: 319-339. Berlin-Heidelberg-New York: Springer-Verlag.

Sokolov, V.E. (ed.) 1982. *The Yuribei Mammoth*. Moscow: Nauka (in Russian).

Stuart, A.J. 1991. Mammalian extinctions in the Late Pleistocene of Northern Eurasia and North America. *Biological Reviews of the Cambridge Philosophical Society* 66 (4): 453-562.

Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, G., van der Plicht, J., & Spurk, M. 1998. INTCAL98 radiocarbon age calibration, 24,000-0 cal BP. *Radiocarbon* 40 (3): 1041-1083.

Sulerzhitsky, L.D. 1997. Patterns of the radiocarbon chronology of mammoths in Siberia and northern Eastern Europe (as sub-stratum for human dispersal). In A.A. Velichko & O. Soffer (eds.), *Humans settlement of the Planet Earth*: 184-202. Moscow: Institute of Geography (in Russian).

Tseitlin, S.M. 1979. *Geology of the Paleolithic of Northern Asia*. Moscow: Nauka (in Russian).

Ukraintseva, V.V. 1990. New paleobotanical and palynological evidences of the Early Holocene warming in the High Arctic. *Botanical Journal* 75 (1): 70-74 (in Russian).

Vasil’chuk, Y., Punning, J.-M., & Vasil’chuk, A. 1997. Radiocarbon ages of mammoths in Northern Eurasia: Implications for population development and Late Quaternary environment. *Radiocarbon* 39 (1): 1-18.

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The Late Quaternary extinction of woolly mammoth (*Mammuthus primigenius*), straight-tusked elephant (*Palaeoloxodon antiquus*) and other megafauna in Europe

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We are engaged in a research project (funded by the Natural Environment Research Council - NERC) on megafaunal extinctions throughout Europe within the period ca. 50,000 to 9000 ^{14}C years BP. The work involves a survey of stratigraphic information and available ^{14}C dates, and also sampling crucial material for a major programme of AMS ^{14}C dating. Both of the elephant species present in the European Late Pleistocene: *Mammuthus primigenius* and *Palaeoloxodon antiquus* are included in the project.

Our target species include most of those that became extinct, or regionally extinct, after ca. 15,000 BP: woolly mammoth *Mammuthus primigenius*, woolly rhinoceros *Coelodonta antiquitatis*; giant deer *Megaloceros giganteus*; lion *Panthera leo*; and spotted hyaena *Crocuta crocuta*. We are also targeting species which retreated to the south of Europe (Iberia, Italy, Balkans) prior to extinction, probably before 20,000-30,000 BP: straight-tusked elephant *Palaeoloxodon antiquus*; narrow-nosed rhinoceros *Stephanorhinus hemitoechus* (perhaps also Merck's rhinoceros *Stephanorhinus kirchbergensis*); and hippopotamus *Hippopotamus amphibius*.

Radiocarbon dating of samples of elephants and other European megafauna is currently in progress, and we are actively seeking more material to be dated.

The strategy is to follow in some detail the patterns of shrinking geographical distributions that preceded extinction. From the data available at present, it is apparent that these range changes were not the same for each species; for example the "last stands" of *Mammuthus primigenius, Megaloceros giganteus* and *Palaeoloxodon antiquus* appear to have been made in very different regions of Europe. Tracking these changes involves firstly gathering data from the literature and from colleagues in each region. By these means we are building up an approximate picture and specifying the likely latest material of our target species for each region. In order to obtain a much more accurate database, we are sampling the putatively latest material and submitting it for ^{14}C dating.

Late Quaternary extinctions have been variously attributed to overkill by human hunters (Martin 1984; Martin & Steadman 1999), to environmental changes (Graham & Lundelius 1984; Graham 1990; Guthrie 1984, 1990; Lister & Sher 1995) and more recently to "hyperdisease" (MacPhee & Marx 1997). Stuart (1991, 1999) has proposed that the proximate cause was hunting by humans, but only when megafaunal populations were already stressed and reduced in numbers and geographical range by major climatic changes. Our current project aims to test these rival hypotheses in Europe by seeking correlations between ^{14}C dated extinction patterns and proxy data for climatic/environmental changes on the one hand, and the appearance of modern humans and upper palaeolithic artefacts on the other.

Woolly mammoth *Mammuthus primigenius*, widespread over most of Europe in the Last

Cold Stage, became extinct during the Late Glacial (Stuart 1991). There are a number of records from north-western and central Europe as late as 13,000 to 12,000 BP, but none so far after this time. Woolly mammoth may have retreated first from southern Europe, and it is anticipated that forthcoming dates will clarify this picture. Our research on mammoth extinction in Europe links with ongoing work in Siberia and the Russian Far East (Orlova *et al*. 2000; Sher 1997).

In marked contrast, *Palaeoloxodon antiquus* was widespread in north-western, central and southern Europe ca. 120,000 BP ("Last Interglacial", Oxygen Isotope Stage 5e) (Stuart 1991). Prior to extinction, we hypothesise that it retreated to southern Europe (Iberia, Italy, and probably the Balkans) in the early part of the Last Cold Stage (OIS 4 and possibly OIS 3), presumably in response to climatic cooling and a similar contraction in range of temperate vegetation. It may prove difficult to determine the timing of its extinction with any accuracy, as *Palaeoloxodon* material of this age is very rare, and much or all of it close to or beyond the range of ^{14}C dating.

REFERENCES

Graham, R.W. 1990. Evolution of new ecosystems at the end of the Pleistocene. In L.E. Agenbroad, J.I. Mead & L.W. Nelson (eds.), *Megafauna and Man*. Flagstaff: North Arizona Press.

Graham, R.W. & Lundelius, E.L. 1984. Coevolutionary disequilibrium and Pleistocene extinctions. In P.S Martin & R. G. Klein (eds.), *Quaternary Extinctions, a Prehistoric Revolution*. Tucson: University of Arizona Press.

Guthrie, D.E. 1984. Mosaics, allochemicals and nutrients. In P.S Martin & R. G. Klein (eds.), *Quaternary Extinctions, a Prehistoric Revolution*. Tucson: University of Arizona Press.

Guthrie, D.E. 1990. Late Pleistocene faunal revolution: a new perspective on the extinction debate. In L.E. Agenbroad, J.I. Mead & L.W. Nelson (eds.), *Megafauna and Man.* Flagstaff: North Arizona Press.

Lister, A.M. & Sher, A.V. 1995. Ice cores and mammoth extinction. *Nature* 378: 23-24.

MacPhee, R.D.E. & Marx, P.A. 1997. The 40,000 year plague; humans, hyperdisease and first contact extinctions. In S.M. Goodman & B.D. Patterson (eds.), *Natural Change and Human Impact in Madagascar*: 169-217. Washington D.C.: Smithsonian Institution Press.

Martin, P.S. 1984. Prehistoric overkill: a global model. In P.S. Martin & R. G. Klein (eds.), *Quaternary Extinctions, a Prehistoric Revolution.* Tucson: University of Arizona Press.

Martin, P.S. & Steadman, D.W. 1999. Prehistoric extinctions on islands and continents. In R.D.E. MacPhee (ed.), *Extinctions in Near Time; Causes, Contexts and Consequences*. New York: Kluwer Academic/Plenum Publishers.

Orlova, L.A., Kuzmin, Y.V., & Zolnikov, I.D. 2000. Time-space systematics for mammoth (*Mammuthus primigenius* Blum.) and prehistoric humans in Siberia (on the basis of radiocarbon dating). *Archaeology, Ethnology, and Anthropology of Eurasia* 1 (3): 31-41.

Sher, A.V. 1997. Late-Quaternary extinction of large mammals in northern Eurasia: A new look at the Siberian contribution. In B. Huntley, W. Cramer., A.V. Morgan, H.C. Prentice & J.R. M. Allen. (eds.), *Past and future rapid environmental changes: The spatial and evolutionary responses of terrestrial biota*: 319-339. Berlin-Heidelberg-New York: Springer-Verlag.

Stuart, A.J. 1991. Mammalian extinctions in the late Pleistocene of northern Eurasia and North America. *Biological Reviews* 66: 453-562.

Stuart, A.J. 1999. Late Pleistocene megafaunal extinctions; a European perspective. In: R.D.E. MacPhee (ed.), *Extinctions in Near Time; Causes, Contexts and Consequences*. New York: Kluwer Academic/Plenum Publishers.

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Landscape, climate and mammoth food resources in the East European plain during the Late Paleolithic

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SUMMARY: The second half of the Late Pleistocene was a time when *Mammuthus primigenius* existed in the East European Plain. Under conditions of great aridity most of the modern tundra, forest and steppe zones were replaced by a periglacial hyperzone. To estimate food supply for mammoths, data on productivity and food value of modern plant communities (analogs of Pleistocene periglacial vegetation) were used.

1. INTRODUCTION

The second half of the Late Pleistocene was a time when *Mammuthus primigenius* existed in the East European Plain. Under conditions of great aridity most of the modern tundra, forest and steppe zones were replaced by a periglacial hyperzone. To estimate food supply for mammoths, data on productivity and food value of modern plant communities (analogs of Pleistocene periglacial vegetation) were used.

The most favorable conditions for mammoths existed in the west-central part of the periglacial hyperzone. It was relatively rich in food resources and water (rivers fed by glaciers and thermokarst lakes). The productivity of plant communities reached 800-1700 kg/ha for periglacial steppe and 2500 kg/ha for meadows. Warming at the transition to the Holocene was accompanied by permafrost degradation, development of bogs, and an increase in snow, unfavorable to the existence of mammoth. Therefore mammoths could not survive these climate conditions at the glacial/interglacial transition.

The Late Pleistocene species *Mammuthus* primigenius (Blumembach) inhabited periglacial areas of Northern Eurasia. The time at which mammoth of so-called early type was replaced by typical *Mammuthus primigenius* can be inferred from the data on Paleolithic campsites along the Dniester River. Mousterian layers at these sites contain mammoths of early type, while the late mammoth remains are found in the Late Paleolithic layers (Chernysh 1982; Ivanova 1977). According to radiocarbon dates on the cultural layers of the Dniester sites, the Mousterian culture persisted here until 35–40 ka BP, and the Late Paleolithic appeared about 30 ka BP.

2. SPATIAL ENVIRONMENTAL RECONSTRUCTIONS OF THE TYPICAL MAMMOTH EPOCH

The great majority of typical mammoth remains are dated to the Pleniglacial, including the period of maximum cooling and extremely severe cryogenic conditions (20 to 18 ka BP, OIS2, Shackleton 1987). The major part of the East European Plain was within permafrost limits (Velichko & Nechaev 1984, 1992). In the north (north of 57–56° N) the frozen ground was up to 200 m thick, with widespread ice wedges. Permafrost reached as far south as 48–49° N.

Under extra-arid conditions, a vast hyperzone of periglacial, primarily open landscapes occurred in place of the modern tundra, boreal forests and steppes (Velichko 1984). According to Grichuk (1982), a narrow strip along the ice sheet margin was covered by a complex vegetation consisting of tundra and steppe-type herb communities, with local open woodlands of birch and pine, while larch was present in the northeast. Farther south, vast interfluves were dominated by periglacial steppe vegetation, with pioneer plants on disturbed or immature soils. Meadow occurred in wetter habitats, such as the dried floors of thermokarst depressions. In more favorable biotopes, spruce, larch and *Pinus sibirica* occurred in open woodlands along with birch and pine, as well as cold-tolerant shrubs (*Betula nana, B. humilis, Alnaster fruticosus*). The southern part of periglacial area was occupied by periglacial steppe, with tree species less frequent even within the river valleys.

According to the paleoclimatic reconstructions for the time of greatest Late Pleistocene cooling (Velichko 1984), winter temperatures were as low as –39° C, that is, 10 to 15° C below those of today in the north, and 20 to 22° in the south of the East European periglacial region. In the north summer temperatures were 5 to 7°C lower than present, and 4 to 5°C lower in the south. The total annual precipitation was about 350 mm or less; attributable to the fact that in high and middle latitudes the Atlantic Ocean was under ice for the major part of the year.

3. The Existence of Mammoths in Periglacial Environments

A herd of mammoths included 10 to 30 individuals on the average (remains of 33 or 34 mammoths are found in the Sevsk site, the Desna drainage basin, 55% of them belonged to mature individuals – Mashchenko 1998). By analogy with present-day elephants, it seems reasonable to suggest that daily need of one adult mammoth amounted to about 175–200 kg of plant material.

To estimate the quantity of available foodstuff, one can use data on productivity and nutritive value of those types of modern herb and grass vegetation which may be considered as analogous to Pleistocene periglacial communities. Steppe meadows (closely resembling communities of river valleys in the periglacial zone) yield about 800 to 1700 kg/ha per year (Nomokonov 1978). Wetter meadows and high grass communities typical for wetter biotopes could produce up to 2000–2500 kg/ha (judging from modern mesic floodplain meadows). Periglacial steppe communities on high terraces and interfluves were less closed and therefore less productive; they were comparable with meadows, however, in nutritive value and protein content. Dry floors of thermokarst lake basins (typical of periglacial cryogenic complex) were covered with highly productive – up to 2500 kg/ha – grazing areas (Tomirdiaro 1980; Ustinov 1978). To estimate the area needed for a mammoth herd, the productivity of periglacial herb and grass communities was taken as 2000 kg/ha, and daily food requirements for an adult mammoth – as 200 kg (though it could be in fact 150 or 175 kg), and an average number of animals in a herd is about 30, of which more than a half are mature, and the rest are young animals. Total vegetable mass daily consumed by the herd is taken as equivalent to that eaten by 20 adult animals. Therefore, the daily requirements of plant material of the herd may be estimated at 4000 kg; the product of 2 hectares. Accordingly, the herd would require 60 hectares of grazing area per month, and about 7 km^2 per year.

Geomorphologically, the area inhabited by mammoths was not uniform, and particular types of terrain were differently used according to season. In summer, the floodplains were too wet (due to floods and melting of seasonally frozen soils) and the soft ground could not support mammoths with their great weight and rather small feet. At that time the herds would prefer dry sites on high interfluves covered with loess. It should be taken into account, when estimating the required grazing area, that even in summer, when the animals could forage over vast interfluvial plains, part of the area was inaccessible because of cryogenic features; so the grazing area must be estimated as three to four times greater than the value given above.

In winter, interfluves could not support mammoth herds. In river valleys, however, frozen ground of floodplains made it accessible for mammoths which could easily feed on grass and bushes grown during summer, especially as snow cover was usually thin. The main reason of the seasonal migrations from one type of biotope to another was access to water. Even in winter, at low temperatures, one mammoth would require about 150 liters per day (Haynes 1993), and a herd under consideration would take 20 times as much. Stable sources of water could be icings in river channels. As follows from calculations, a conventional mammoth herd needs about 4 hectares of grazing area per day, that is about 10 km^2 for the whole cold season (about 7 months). Making allowance for unproductive areas (the river channel, oxbow lakes, point bars, and sites heavily disturbed by cryogenic fissures), the required area may increase by an order of magnitude, that is, up to 100 km^2. Taking the width of floodplain and lower terraces to be 2 to 5 km, a herd would require a section of valley about 30 to 40 km long.

A consequence from the above is that the food supply, and therefore potential abundance of mammoths, would have varied considerably from warm to cold season within the same region. To take one example, we consider the region known for its Late Paleolithic sites in the middle reaches of the Desna River about 20,000 to 25,000 km^2 in area. In summer it could support several hundred mammoth herds, while only 10 to 20 herds could survive through the winter. Evidently, such a drastic reduction in food resources during the cold season put a limitation on mammoth population in the periglacial regions.

4. General Pattern of Mammoth Distribution

The west central part of the Late Pleistocene periglacial hyperzone was the most favorable for mammoths; as is strongly suggested by the fact that most mammoth finds are concentrated there. The abundance of fossil remains decreases both eastward and southward, which is probably attributable to drier climate and consequently more scarce and less productive periglacial vegetation. Northern regions were even less suitable for mammoths because of low productive capacity of tundra plant communities and poor fodder base.

At the time of maximum cooling, mammoth was the main source of food for Late Paleolithic man, and humans would follow mammoth. Thus, in the east of the periglacial zone environments were unsuitable for mammoth, and this region practically lacks Paleolithic campsites (Velichko & Kurenkova 1990).

A typical mammoth was adapted to specific conditions of periglacial landscapes and climates, and the drastic change in climate and biotopes at the Pleistocene/Holocene boundary resulted in its extinction.

5. Acknowledgements

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6. References

Chernysh, A.P. 1977. Multi-layered Paleolithic campsite Molodova 1. In G.I. Goretsky, S.M. Tseitlin (eds.), *Mnogosloinaya paleoliticheskaya stoyanka Korman' IV na srednem Dnestre*. (Multi-layered Paleolithic site of Korman IV in the middle reaches of the Dniester): 188-235. Moscow: Nauka (In Russian).

Grichuk, V.P. 1982. Vegetation of Europe in the Late Pleistocene. In I.P. Gerasimov & A.A. Velichko (eds.), *Paleogeografiya Evropy za poslednie sto tysyach let.* (Paleogeography of Europe during the last hundred thousand years): 92-109. Moscow: Nauka (In Russian).

Haynes, G. *Mammoths, mastodonts and elephants. Biology, behavior and the fossil records*: 413 p. Cambridge: Cambridge University Press.

Ivanova, I.K. 1977. Geology and paleogeography of the Korman IV site against the background of the geological history of the Paleolithic in the Middle Dniester region. In G.I. Goretsky, S.M. Tseitlin (eds.), *Mnogosloinaya paleoliticheskaya stoyanka*

Korman' IV na srednem Dnestre. (Multilayered Paleolithic site of Korman IV in the middle reaches of the Dniester): 126-170. Moscow: Nauka (In Russian).

Mashchenko, E.N. 1998. *Skelet i zubnaya sistema v individual'nom razvitii Mammuthus primigenius* (Blum. 1799) (Proboscidia, Elephantidae) *i nekotorye cherty biologii mamonta* (Skeleton and tooth system in individual development of *Mammuthus primigenius* (Blum. 1799) (Proboscidia, Elephantidae) and some features of mammoth biology). *Avtoreferat diss. kand. biol. nauk, PIN RA*: 24. Moscow (In Russian).

Nomokonov, L.I. 1978. Floodplain meadows of Siberia. In T.S. Khachaturov (ed.), *Estestvennye kormovye resursy SSSR i ikh ispol'zovanie* (Natural forage resources of the USSR and their use): 79-93. Moscow: Nauka (In Russian).

Shackleton, N.J. 1987. Oxygen isotopes, ice volume and sea level. *Quaternary Sciences Reviews,* 6: 183-190.

Tomirdiaro, S.V. 1980. *Loessovo-ledovaya formatsia Vostochnoi Sibiri v pozdnem pleistotsene i golotsene* (Loess-ice formations of East Siberia in the late Pleistocene and Holocene): 184. Moscow: Nauka (In Russian).

Ustinov, V.I. 1978. Natural forage resources of the Magadan Region and reindeer breeding. In T.S. Khachaturov (ed.), *Estestvennye kormovye resursy SSSR i ikh ispol'zovanie* (Natural forage resources of the USSR and their use): 168-177. Moscow: Nauka (In Russian).

Velichko, A.A. & Kurenkova, E.I. 1990. Environmental conditions and human occupation of Northern Eurasia during the Late Valdai. In O. Soffer, C. Gamble. (eds.), *The World at 18,000 BP*, 1: 255-265. London: Unwin Hyman.

Velichko, A.A. & Nechaev, V.P. 1984. Late Pleistocene permafrost in European part of the USSR. In A.A.Velichko (ed.), *Late Quaternary environments of the Soviet Union*: 261-285. Minneapolis: University of Minnesota Press.

Velichko, A.A. & Nechaev, V.P 1992. Cryogenic regions during the Last Glacial Maximum (permafrost). In B. Frenzel, M. Pesci, A.A. Velichko (eds.), *Atlas of paleoclimates and paleoenvironments of the Northern Hemisphere (Late Pleistocene - Holocene)*: 103-104. Stuttgart, Budapest.

Velichko, A.A. 1984. Late Pleistocene paleoclimatic reconstructions. In A.A. Velichko (ed.), *Late Quaternary environments of the Soviet Union*: 261-285. Minneapolis: University of Minnesota Press.

L’avorio in Italia nell’Età del Bronzo

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SUMMARY: This text is a concise presentation of the round table on the problems concerning ivory in Italian protohistory. This is a subject to which, to date, little attention has been devoted by scholars, both because of the rare occurrence of this material in archaeological contexts and because researches on the manufacture of animal teeth, bone and antler are of very recent tradition in studies on Italian protohistory.

The round table, therefore, aims at introducing a debate in order to define the state of knowledge and also to promote a greater interest towards this subject. This first and preliminary step represents a premise to the recognition and systematic gathering of data concerning this class of materials and to a full comprehension of the role of ivory manufacture in the field of specialised protohistorical production.

La problematica relativa alla lavorazione dell’avorio e alla sua circolazione in Italia e nelle isole durante l’età protostorica, in particolare nel corso dell’età del bronzo, è un argomento ancora assai poco studiato nel suo insieme. Molto rare sono le situazioni nelle quali è stata sviluppata un’adeguata indagine circa il riconoscimento delle materie prime: isolato appare per ora il caso di Frattesina, insediamento localizzato nella pianura padana dove è stata individuata la lavorazione *in loco* di questo materiale a partire dal Bronzo finale (Bietti Sestieri & de Grossi Mazzorin 2001). In molti casi la difficoltà di identificare la materia prima, in assenza di strumentazione adeguata e – in generale – la scarsa conoscenza dei metodi di riconoscimento da parte degli archeologi, hanno prodotto definizioni per lo più ambigue e poco compromettenti dei reperti. Inoltre, a questo argomento non sono stati mai dedicati studi che abbiano analizzato le modalità, e le eventuali variazioni, nella circolazione dell’avorio grezzo o lavorato.

Nell’età del Bronzo altri sono i materiali di origine esotica, o comunque alloctona, per i quali esiste una ricca tradizione di studi; si pensi alla ceramica d’importazione egea (Taylour 1958; Biancofiore 1967; Vagnetti 1982) o all’ambra, la cui diffusione in età protostorica è documentata in Italia con l’inizio dell’età del Bronzo. Per quest’ultimo materiale gli studi sul riconoscimento della provenienza, generalmente dall’area baltica, sono stati avviati negli anni Sessanta, ma già in precedenza, a partire dagli anni Trenta, erano state sviluppate le prime ipotesi sui percorsi utilizzati per la sua circolazione (de Navarro 1925; Negroni Catacchio 1989, 1999).

Lo studio sistematico dei manufatti in osso e corno presenti negli insediamenti della penisola italiana è diventato una pratica piuttosto comune solo negli ultimi decenni (Provenzano & Rossi 1988; Provenzano 1997; De Marinis 1999), ma sarebbe necessario lo studio e la pubblicazione sistematica dei *corpora* di manufatti provenienti dagli insediamenti dell’età del bronzo Italia per poter valutare l'effettiva importanza della lavorazione delle materie dure animali nell'ambito delle produzioni artigianali specializzate di età protostorica (Peroni 1994). È peraltro indubitabile che, nel periodo considerato, l'utilizzazione dell'avorio sia stata marginale rispetto a quella delle altre materie dure animali: non può quindi sorprendere il fatto che, per il momento, non si sia sviluppato uno specifico filone di indagine.

La realizzazione del Congresso "La Terra degli Elefanti", la cui impostazione molto articolata lascia spazio anche alle problematiche relative alla presenza dei Proboscidati oltre i confini cronologici della preistoria più antica - durante la quale ben altra è l'importanza nel record archeologico e nelle problematiche generali delle diverse specie di elefanti - è sembrata un'occasione opportuna per avviare un dibattito che coinvolgesse l'età protostorica. La possibilità di organizzare una tavola rotonda sull'argomento è dunque parsa un'occasione propizia per iniziare questo percorso, sensibilizzando i colleghi su questo problema.

In questo workshop si è scelto di organizzare l'incontro in modo estremamente informale, nell'intento di stimolare la discussione e lo scambio di idee.

Numerosi sono gli studiosi che hanno dato la loro adesione all'iniziativa:

Rosamaria Albanese (Istituto di Archeologia dell'Università di Catania), Gabriele Baldelli (Soprintendenza Archeologica delle Marche), Anna Maria Bietti Sestieri (Soprintendenza Archeologica dell'Abruzzo), Salvatore Chilardi (Soprintendenza BB.CC.AA. di Siracusa), Maria Cristina De Angelis (Soprintendenza Archeologica dell'Umbria), Jacopo de Grossi Mazzorin (Soprintendenza Archeologica di Roma-Palazzo Altemps), Riccardo Guglielmino (Scuola Normale Superiore di Pisa e Università di Lecce), Noëlle Provenzano (Università di Aix-en-Provence), Rosalba Panvini (Soprintendenza BB.CC.AA. Caltanissetta - Sez. Archeologica), Anna Maria Tunzi (Soprintendenza Archeologica per la Puglia), Paola Villa (Dipartimento di Scienze della Terra, Università La Sapienza - Roma), Alessandro Zanini.

Ad una breve introduzione ai lavori di Lucia Vagnetti segue l'intervento del Prof. François Poplin, del Musée d'Histoire Naturelle di Parigi che illustra i problemi specifici della materia prima e della sua provenienza, delle tecniche di lavorazione, delle problematiche relative alla circolazione in area mediterranea.

La discussione sui dati specificamente italiani è articolata in diverse parti, per permettere di indirizzare i lavori su alcune tematiche principali.

Nella prima parte sono presi in considerazione i manufatti di avorio dei quali è stata ipotizzata l'importazione, rinvenuti in contesti dell'età del bronzo dell'Italia centro-meridionale e insulare (Puglia, Sicilia e Sardegna). Intervengono R. Guglielmino, R. Panvini, A.M. Tunzi, L. Vagnetti.

La seconda parte riguarda la lavorazione delle materie dure animali, ed in particolare dell'avorio, sulla base della documentazione presente nei contesti italiani dell'età del bronzo.

Intervengno A.M. Bietti Sestieri, S. Chilardi, J. de Grossi Mazzorin, N. Provenzano, L. Vagnetti, P. Villa.

Nella terza parte sono infine passati in rassegna i manufatti di avorio che una serie di indicatori segnalano come prodotti in alcuni insediamenti italiani. Si tratta di manufatti rinvenuti sia in insediamenti sia in necropoli della penisola italiana e della Sicilia.

Intervengono R. Albanese, G. Baldelli, A. Bietti Sestieri, I. Damiani, M.C. De Angelis, J. de Grossi Mazzorin, L. Vagnetti, A. Zanini.

Obiettivo della tavola rotonda è prima di tutto quello di fare il punto dello stato degli studi sulla presenza e lavorazione dell'avorio nel periodo considerato, facendo incontrare tra loro quegli studiosi che hanno già avuto occasione di studiare contesti archeologici nei quali sono stati riconosciuti manufatti in avorio, ma più in generale è anche quello di stimolare l'attenzione e l'interesse dei colleghi su un argomento finora troppo trascurato. Tale filone di studi sembra invece degno della massima attenzione, sia per quanto riguarda le questioni relative alla natura, al reperimento e alla circolazione di materie prime pregiate (avorio fossile o da animali contemporanei?; elefante asiatico, elefante africano o ippopotamo?), sia per il contributo che può apportare alla definizione e alla comprensione di pratiche artigianali specializzate. Non si può infine tralasciare il valore simbolico del quale alcuni manufatti possono essere portatori, che andrà indagato in relazione ai contesti di ritrovamento e alle specifiche tipologie.

In sintesi ci auguriamo che da questo incontro possa nascere una ricerca sistematica sul corpus dei manufatti di avorio provenienti da contesti italiani nell’età del bronzo, che veda impegnati archeologi e naturalisti in un rapporto di proficua collaborazione.

BIBLIOGRAFIA

Bietti Sestrieri, A.M., De Grossi Mazzorin, J. 2001. L’avorio dell’abitato protostorico di Frattesina (Ro). *This volume.*

Caubet, A. & Poplin, F. 1987. Les objets de matiere dure animale. Étude du materiaux. In M. Yon (ed.), *Ras Shamra-Ougarit, III, Le centre de la ville, 38°-44° Campagnes (1978-1984)*: 273-306. Paris: Edition Recherche sur les Civilisations.

Chavane, M.J. 1980. L’os et l’ivoire a Chypre de l’époque néolithique à l’époque classique: inventaire. In D. Strodeur (ed.), *Objets en os historique et actuel*: 19-40. Lyon: Presses Universitaires de Lyon.

De Hoff, S.L. 1988. *The Ivory Trade in the Eastern Mediterranean Bronze Age: Background and Preliminary Investigation*. Ph.D. Dissertation, University of Minnesota.

De Marinis, G. 1999. L’insediamento dell'età del Bronzo di Moscosi di Cingoli. 3. L’industria su corno di cervo e la produzione bronzistica: considerazioni tecnologiche. *In Piceni, popolo d’Europa*: 46-47. Roma: Edizioni De Luca.

Fitton, J.L. (ed.) 1992, *Ivory in Greece and the Near Eastern Mediterranean from the Bronze Age to the Hellenistic Period*. London.

Jones, R.E. 1986. Chemical Analysis of Aegean-Type Late Bronze Age Pottery found in Italy. In M. Marazzi, S. Tusa, L. Vagnetti (eds.), *Traffici micenei nel Mediterraneo*: 205-214. Taranto: Istituto per la Storia e l’Archeologia della Magna Grecia.

Jones, R.E. & Vagnetti, L. 1991. Traders and craftsmen in the Central Mediterranean: Archeological Evidence and archaeometric research. In N.H. Gale (ed.), *Bronze Age Trade in the Mediterranean.* Jonsered: Paul Åströms Förlag.

Krzyszkowska, O. 1990. *Ivory and Related Materials: An Illustrated Guide.* London: Institute of Classical Studies.

Navarro, de J.M. 1925. Prehistoric Routes between Northern Europe and Italy Defined by the Amber Trade. *Geographical Journal* 66: 481-504.

Negroni Catacchio, N. 1989. L’ambra: produzione e commerci nell’Italia preromana. *In Italia Omnium terrarum parens*: 659-696. Milano: Libri Scheiewiller.

Negroni Catacchio, N. 1999. N. Negroni, Produzioni e commercio dei vaghi d'ambra tipo Tirinto e tipo Allumiere alla luce delle recenti scoperte. *In Preistoria e protostoria del Venetorum Angulus. Atti XX Convegno di Studi Etrusco-Italici*: 241-65. Pisa-Roma: Istituti Editoriali e Poligrafici Internazionali.

Peroni, R. 1994. *Introduzione alla protostoria italiana*. Roma-Bari: Editori Laterza.

Poursat, J.C. 1977. *Les ivoires mycéniens. Essai sur la formation d'un art mycénien.* Athens.

Provenzano, N. & Rossi G. 1988. in *La terramara di Castione dei Marchesi. Studi e documenti di Archeologia* 5: 167-205. Bologna: Nuova Alfa Editoriale.

Provenzano, N. 1997. Produzione in osso e corno delle terramare emiliane. In M. Bernabò Brea & A. Cardarelli et M. Cremaschi (eds.), *Le terramare. La più* *antica civiltà padana*: 524-544. Milano: Electa.

Taylour, W. 1958. *Mycenaean Pottery in Italy and Adjacent Areas*. Cambridge: Cambridge University Press.

Vagnetti, L. 1982. *Magna Grecia e mondo miceneo. Nuovi documenti*. Taranto: Istituto per la Storia e l’Archeologia della Magna Grecia.

L’avorio dell’abitato protostorico di Frattesina (Rovigo, Italia)

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SUMMARY: The protohistoric complex of Frattesina di Fratta Polesine (XIII/XII-VIII century BC) comprises a large settlement, extending over 9 ha, and two cremation cemeteries. Systematic surveys and excavations have been carried out since 1974. The economic basis shows some interesting features, which apparently are quite exceptional in Late Bronze and Early Iron Age Italy. Frattesina was a true industrial site, in which artifacts of glass-paste, bone and antler, elephant ivory, bronze and other metals, possibly amber were produced on a very large scale, as is indicated by the presence of both finished objects and discard. The local processing of ivory is an indication of the involvement of Frattesina in the wider context of long-distance trade in the Mediterranean regions, in the period between the end of the Mycenaean sailings and the beginning of the Greek colonisation. The identification of the type of ivory which was worked at Frattesina is relatively simple: all the pieces show the Schreger lines, a feature exclusive to elephant ivory. The low degree of mineralization indicates that the raw material was not fossil ivory.

Il complesso protostorico di Frattesina di Fratta Polesine (RO), databile fra la tarda età del bronzo e gli inizi dell’età del ferro (ca. XII-VIII sec. a.C.) comprende un vasto insediamento, esteso per oltre nove ettari, e due necropoli prevalentemente a incinerazione. Scavi regolari, accompagnati da raccolte sistematiche di superficie, sono in corso dal 1974, e hanno rimesso in luce alcune strutture dell’abitato e un totale di circa 650 tombe. Dal momento della scoperta, l’area dell’abitato è stata anche oggetto di numerosissime raccolte di superficie non sistematiche.

Il maggior elemento di interesse di questo complesso consiste nelle caratteristiche del tutto eccezionali della sua economia: si tratta infatti di un vero e proprio centro industriale, nel quale si producevano su larga scala oggetti di pasta vitrea, osso e corno di cervo, avorio, bronzo e altri metalli, forse ambra.

Alcune delle attività artigianali che si svolgevano nell’abitato, e dei materiali che vi si rinvengono con minore frequenza, indicano collegamenti sistematici transmarini, probabilmente con l’area del Mediterraneo Orientale. La lavorazione dell’avorio di elefante avveniva certamente sul posto, come è indicato dall’abbondanza di oggetti finiti e di scarti di lavorazione. Dall’abitato vengono anche alcuni frammenti di ceramica di argilla depurata e dipinta, con confronti nella produzione tardomicenea e protogeometrica ma probabilmente di produzione locale.

Collegamenti a lunga distanza con tutto il territorio italiano e con le isole maggiori sono indicati dalla vasta distribuzione di alcuni dei principali tipi noti a Frattesina (perle di pasta vitrea e ambra, pettini di avorio) in numerosi complessi contemporanei; inoltre, la produzione metallurgica mostra uno stretto rapporto con la zona metallifera dell’Etruria.

L'insieme delle caratteristiche del complesso di Frattesina indica un suo ruolo specifico, finora senza confronti, nel quadro della produzione artigianale e dello scambio in Italia fra la tarda età del bronzo e gli inizi dell’età del ferro. La presenza di oggetti e materie prime di origine orientale sembra indicare che questo ruolo si colloca nell’ambito più vasto degli scambi in area mediterranea che si sviluppano nel periodo compreso fra la fine delle navigazioni micenee e gli inizi della colonizzazione greca.

Nelle raccolte di superficie e nelle campagne di scavo condotte nell’abitato sono stati recuperati, in contesti riferibili alla fine dell’età del bronzo, oltre a oggetti di avorio finiti (pettini, manici di coltello, bastoncini decorati ecc.) numerosi scarti di lavorazione e pezzi in uno stadio di lavorazione più o meno avanzato.

L'identificazione del tipo di materia prima utilizzata a Frattesina è relativamente semplice: su tutti i pezzi si osserva la presenza delle linee di Schreger caratteristiche esclusivamente dell'avorio elefantino. Le linee di Schreger si possono notare sulle sezioni trasversali come linee curve che dal centro si irradiano parallele tra loro sia in senso orario che antiorario a formare un reticolo di piccoli rombi (Shoshani 1996). Questo reticolo è ben visibile nel materiale di Frattesina, sia in alcune sezioni trasversali segate che su alcuni frammenti spezzati sempre in senso trasversale.

Per quanto riguarda Frattesina finora non è stato possibile stabilire se l’avorio sia da attribuire a elefanti africani o asiatici anche se attualmente si sta tentando tramite l’ausilio della microscopia elettronica a scansione e dell’analisi del DNA di discriminare i resti di avorio in oggetto. È invece possibile escludere, in base al grado di mineralizzazione, che possa essere di origine fossile. Di conseguenza è praticamente certo che la materia prima proveniva da una delle aree in cui gli elefanti vivevano all'epoca dell’abitato.

La distribuzione degli elefanti asiatici (*Elephas maximus*) raggiunse in passato l’Asia occidentale, ma a causa della scarsità di prove sulla sua presenza prima degli inizi del II millennio a.C. diversi autori hanno ipotizzato che questi animali siano stati introdotti deliberatamente dall’uomo dal sub-continente indiano (Barnett 1982; Clutton-Brock 1987; Krzyszkowska 1990). Anche l’elefante africano, specie nella c.d. varietà di foresta (*Loxodonta africana cyclotis*), aveva in passato una distribuzione abbastanza estesa che includeva le regioni mediterranee (Egitto, Libia) fino ai piedi dell’Atlante.

BIBLIOGRAFIA

Barnett, R.D. 1982. Ancient Ivories in the Middle East and Adjacent Areas. *Qedem* 14: 1-100.

Clutton-Brock, J. 1987. *A Natural History of Domesticated Mammals*. London: The Natural History Museum.

Shoshani, J. 1996. Skeletal and other basic anatomical features of elephants. In Shoshani, J. & Tassy, P. (eds.), *The Proboscidea* 2: 8-20. Oxford: Oxford University Press.